Sabbatical Report

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Department of Chemistry

Fall 2008 – Spring 2009

Table of Contents

My sabbatical is dedicated to Deborah Boroch. Without her guidance and encouragement, it would not have been possible. I would have enjoyed sitting down with her over a Diet Coke and discussing my adventures. I am very happy that I had the opportunity to chase fireflies in the National Mall with her. She will be missed . . . and remembered.

ABSTRACT

The purpose of this two-semester sabbatical leave is to develop resources that will encourage science students to make connections between what they learn inside of the classroom and their current personal and future professional lives. It has been demonstrated that students who relate to concepts and topics taught in the classroom will learn better.

A compendium of significant scientific events/breakthroughs/discoveries will be prepared. The preparation of this body of knowledge will be through a combination of course work, travel and research of the scientific literature, including internet resources. The information gathered will be processed into three products: classroom presentation briefs, designs for exhibits in the new display cases in building 7, and ideas for exhibits in the future Natural Science Exploratorium. The presentation briefs will be in the form of PowerPoint presentations that will be stored on the Chemistry Department server, where they will be accessible to all faculty members.

INTRODUCTION

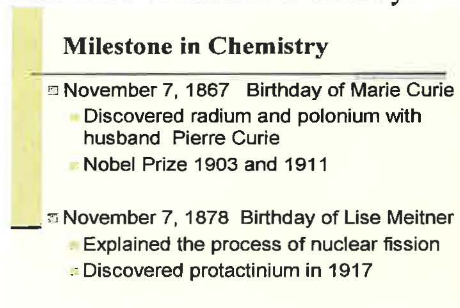
A quarter of a century ago I began my teaching career with a passion for science, a Master's degree in Biochemistry, the desire to be an excellent chemistry teacher, and very little insight on how to achieve this goal! Mt. San Antonio College provided me with an amazing opportunity to develop and grow into a seasoned, effective teacher. When I was hired, the Department was comprised of a group of incredible professors who had helped set the standard for teaching chemistry. With the supervision and mentoring of these role models, my understanding and mastery of chemistry from an instructor's perspective developed. Participation in Professional Development activities such as Langford's "Quality Learning" course and the Developmental Education certification program have allowed my teaching skills to evolve from "chalk-talk" to student-centered activities that present concepts in a manner that is effective to many types of learners. The support of the College allowed the Chemistry Department to become a national leader in the use of computers and technology in chemistry instruction at the community college level. Indeed, my previous sabbatical leave was used to develop materials to integrate data-acquisition technology into the Chemistry Department's laboratory curriculum.

I am now more aware of the challenges that face science (not just chemistry) teachers. Students frequently view the sciences as tedious, boring subjects that have very little connection to their everyday lives and future plans. Textbooks have become thicker as more technical information is included. "Interesting applications" appear in highlighted boxes that are separated from the "real" material. Students only read these boxes if teachers indicate that a question or two might appear on the next exam. Most chapters contain a limited amount of material on the history of the topic. When historical information is included it is usually just isolated facts, not placed in a historical context. The emphasis on "covering the material" frequently minimizes the likelihood of making connections to events outside the realm of the classroom. The resulting lack of relevancy creates a barrier to learning and an indifference to the scientific concepts.

After twenty-five years in the classroom, my definition of what it means to be an excellent chemistry teacher has evolved and expanded. In addition to inspiring students to master the concepts and skills covered in course syllabi, I feel that it is imperative to build awareness, understanding and appreciation of the imprint of science on modern life. Students should be able to relate the concepts and topics taught in the classroom to the world around them. According to Langford's chapter on "Dendrite Farming", students master information faster and better if they see the relevance. As I have gained proficiency in the skills and knowledge necessary to teach chemistry, I have attempted to integrate resource/supplemental material that will generate student interest and life connections.

Here is an example I use that succeeds in creating interest and a historical context for the topic of nuclear chemistry. Nuclear chemistry is presented in our current textbook as a series of equations representing nuclear decay, calculations of binding energy, a discussion of half-life and carbon dating, and an explanation of the processes of fusion and fission. The operation of a nuclear power plant and some medical applications end the chapter. Information about Glenn Seaborg and Darlene Hoffman appear in highlighted boxes. There is little mention of the pre-WWII climate in Europe or the Manhattan project in the United States that stimulated the rapid advances that gave rise to the current state of nuclear chemistry. Students dutifully copy down notes and complete worksheets of drill problems and equations, oblivious to the history lesson that is camouflaged in the names of the elements on the periodic table in the front of the room.

The first slide in the PowerPoint presentation of this example introduces two people who made significant contributions to the field of nuclear chemistry:



Reading the names of elements 92, 93, and 94 out loud immediately catches students' attention: uranium, neptunium and plutonium. Students immediately see the connection between the names of the elements and the planets.

Students then view a QuickTime video clip of an interview with the discoverer of the element plutonium (Glenn Seaborg) where he explains why plutonium is abbreviated P – U (because he realized it was a dangerous, stinky element). The next step is to convey the following information while pointing out the appropriate element on the periodic table:

"Glenn Seaborg was the director of the team that discovered several elements at the Lawrence *(#106 – Lawrencium)* Livermore Laboratory at UC Berkeley *(#97 – Berkelium)* in the state of California *(#98 – Californium)* in America *(#95 – Americium)*. This usually inspires someone to ask about the names of other elements. I can then point out elements #96 – Cm (*curium*) and #84 – Po (*polonium*) that pay tribute to Marie Curie and her Polish ancestry. Elements #99 – Es (*einsteinium*), #109 – Mt (*meitnerium*) and #100 – Fm (*fermium*) introduce scientists who made major contributions to the Manhattan Project.

1 H Hydrogen 1.00794																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.845	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

This begins a discussion of the political climate in Europe in the 1930's, the race between Germany and the U.S. to develop and harness nuclear fission, and the emigration of eminent Jewish nuclear scientists from Nazi Germany. This usually segues into a dialogue about the modern applications of nuclear chemistry that have evolved out of the discoveries and milestones of the nuclear age. Questions are asked about a variety of related topics that are not addressed in the textbook:

> "What's the difference between an atomic bomb and a nuclear bomb? "
> "Are you exposed to radiation when using a microwave oven?"
> "Why is radioactive iodine used to treat thyroid conditions?"

The entire presentation process takes only 10 to 15 minutes, but the interest of students is palpable. Students who haven't uttered a word in class for the entire semester become engaged in the discussion. At the end of this segment, nuclear chemistry is no longer a series of equations to be balanced. Connections have now been made from the concepts of nuclear chemistry to people, places and times in history. Students see the continuum between past and present applications. They can also speculate on future discoveries and applications of nuclear technology.

I have reached a pivotal point in my teaching career. I have set a new goal: to enhance every topic in a manner similar to the example of nuclear chemistry. Students who are stimulated to understand and embrace the relevance of science will attain far more lasting benefits from their education than those who simply memorize material for the next exam. The prohibitive factor is finding the time necessary to research and prepare the resources/supplemental items needed to incorporate historical and pertinent connections into every course that I teach. I have achieved a high level of expertise in the field of chemistry, but there are entire areas (History of Science and Philosophy of Science, for example) to which I have had very little exposure. A two semester sabbatical leave will provide the time necessary to acquire and organize the body of knowledge needed to enhance my classroompresentations.

GOALS AND OBJECTIVES OF PROPOSED SABBATICAL LEAVE

1. Prepare a compendium of ***selected*** significant scientific events/breakthroughs/discoveries that are relevant to Mt. SAC science courses, from the beginning of recorded history to the present time. The preparation of this body of knowledge will be through a combination of course work, travel and research of the scientific literature, including internet resources. ***The compendium will encompass events/breakthroughs/discoveries that can be connected to a topic in one of the Department's courses or will make an appealing and educational visual display.***

2. Select material to enhance classroom presentations. Assemble this material into "presentation briefs" that will contain a historical context, interesting tidbits about noteworthy individuals, pictures, diagrams, video clips, links to internet sites and any other interesting data.

3. Design and develop educational and attention-grabbing visual exhibits that can be mounted in the new Chemistry Department display cases. Outline these exhibits, including suggestions for pictures and objects that need to be acquired.

4. Compile an inventory of possible exhibits for the Natural Science Exploratorium. The list will contain developed ideas and pictures of exhibits that can be created or recreated, along with items needed to complete the displays.

PLAN OF ACTION

I. Compiling the Compendium - Gathering information will entail traveling, intensive internet research and taking appropriate courses. I have done preliminary research to identify activities, courses and venues that will be excellent resources of historic scientific information. In addition to these preselected items, my intention is to embark on a treasure hunt for interesting ideas without following a predetermined list of topics.

C. Tentative Travel Itinerary

1. Philadelphia – August 2008

a. August 17-21 **236th American Chemical Society National Meeting**
Attend symposia in the Division of Chemical Education and the Division of History featuring historical perspectives of science

Explore the accompanying Exposition to search for and examine books and resources related to the History of Science or History of Chemistry

b. August 25-28 **Chemical Heritage Foundation**
Tour the current exhibits in the museum: Transmutation: Alchemy in Art;
Molecules that Matter

Explore and do research at the Donald F. and Mildred Topp Othmer Library of Chemical History: "more than 100,000 volumes of primary resources for the history of the chemical and molecular sciences, technologies, and industries".

Explore and do research at the Roy G. Neville Historical Chemical Library: "works that date from 15th century to 20th century and includes many of the most important works in the history of science and technology".

Explore the Eddleman and Fisher Collection: "fascinating view of alchemy and the alchemists in over 90 paintings and 200 works on paper from the 17th through the 19th century. Other highlights of CHF's collection include portraits of chemistry's forefathers, including Joseph Priestley and Robert Boyle; the *World Brain*, a conceptual artwork that gives an illusion of dimensionality; and *The Alchemist,* by N. C. Wyeth".

c. August 17 – 28 **Unscheduled day times and evenings**
Explore historic sites in the city relevant to Benjamin Franklin and Benjamin Rush, two scientists who signed the Declaration of Independence.

2. New York – August 2008 (after completion of research in Philadelphia)

a. New York Hall of Science - Flushing
Visit the following exhibits: Marvelous Molecules – Secrets of Life, Mathematica: A World of Numbers, Hidden Kingdom: World of Microbes

b. American Museum of Natural History – New York
Visit Exoplanets exhibit

3. **History of Science Study Tour of Bavaria and Austria October 9 – October 22, 2008**

    a. **Munich**
    Visit Deutsches Museum of Munich, European Patent Office, Residenz and the Crown Jewels, Nymphenburg Palace Porcelain Factory and Museum

    b. **Althofen in the Carinthian Alps**
    Private lecture at the Auer von Welsbach Museum (von Welsbach is most famous for his invention of incandescent lighting, but in his spare time, he perfected a formula for cigarette lighter flints that is proprietary information even to this day, and he also discovered several rare earth elements)

    Visit prehistoric iron mine, mineral and gem collection containing samples of minerals found only at the site and nowhere else in the world, the high ovens of Heft where Bessemer-type steel was processed in the 19^{th} century, Heinrich Harrer Cultural Anthropology Museum

    c. **Salzburg**
    Visit salt mines of Berchtesgaden

4. **Spring 2009** – Itinerary to be developed during the end of the fall 2008 semester. Below is a list of possible venues to visit. The locations will be selected based on topics that have not been addressed by the end of November.

    a. **California Science Center – Los Angeles**
    b. **Ruben H. Fleet Science Center – San Diego**
    c. **San Diego Natural History Museum – San Diego**
    d. **California Academy of Sciences Natural History Museum – San Francisco**
    e. **Lawrence Hall of Science – Berkeley**
    f. **The Tech Museum of Innovation – San Jose**
    g. **Bradbury Science Museum – Los Alamos National Laboratory**
    h. **Smithsonian Museums – Washington D.C.**

D. **Study** – The course work will consist of enrolling in at least three courses in the history of science or the philosophy of science. This activity will be undertaken during the winter or spring terms, dependent upon whether the institution is on the quarter or semester system. A list of appropriate, local courses has been compiled. All of these courses are available to the public as extension courses, as long as the prerequisites are met. All courses are currently offered during the winter or spring terms. The actual selection of courses will be made when class schedules become available.

There is no guarantee that the courses listed below will be offered. If it becomes impossible to complete this activity, the committee will be consulted for approval of an alternate activity. Alternate activities may include enrolling in similar online courses, pursuing a course of self-study following a syllabus of a course available on line or an additional research trip and accompanying internet research.

1. **Cal Poly Pomona**

    a. **IGE 320 Visions of Science and Technology (upper division – 4 units)**

    Cultural critiques of science and technology from the perspectives of philosophy, literature and visual arts: representations of 19th century American industrialization and investigation of 20th century proliferations: parallels between modern science and versions of science dating from the ancient world.

    b. **CHM 306 History and Philosophy of Chemistry (upper division – 4 units)**

    The history of chemistry from antiquity to the present, milestones in the development of chemistry and their impact on science and technology. How the chemistry way of knowing (using the scientific method) differs from that used in other disciplines. The philosophical atmosphere in which a particular chemist lived and its limiting or directing influence on the making of that chemist.

2. **University of California, Los Angeles**

    a. **Hist. 3A – Intro. to History of Science: Scientific Revolution (lower division–5 units)**
    Survey of beginnings of physical science involving transformation from Aristotle to Newtonian cosmology, mechanization of natural world, rise of experimental science and the origin of scientific societies.

    b. **Hist. 3B – Intro. to History of Science from Newton to Darwin (lower division–5 units)**
    In this period science became part of the Enlightenment campaign for reason and for the culture of an Industrial Revolution. New social science and evolutionary debates about science and religion demonstrate its rising intellectual and practical significance.

    c. **History 3C – Intro. to History of Science: History of Modern Science, Relativity to DNA (lower division – 5 units)**
    Ranging from starting new physics of relativity and the quantum, and of nuclear weapons, to molecular reductionism in biology and campaigns for statistical objectivity, examination of involvement of science in technological, military, intellectual, and political changes of the 20th century.

    d. **History 180A – Topics in History of Science (upper division – 4 units)**
    Topics may include science and colonialism, science and religion, environmental history, science in Enlightenment, development of theory of evolution, science and public policy, public nature of science.

3. **California State University, Los Angeles**

    CHEM 380N – Ancient and Modern Science (upper division – 4 units)
    Systematic analysis of ancient scientific thought as science and its relationship to modern science

E. **Internet Research** – All topics that are selected will include a historical context, noteworthy individuals, pictures, available video clips and related websites. Information that is not available from the research conducted by travel and courses will be sought electronically. Many museums, science centers and libraries make some of their resources available via the internet. In fact, the Chemical Heritage Foundation allows many of its holdings to be accessed online, which will be very convenient when follow-up is required after returning to California.

1. **Research while traveling**

   I will be traveling with a laptop computer. As I find exciting tidbits of information about an appropriate topic during a visit to museum, or science center, etc., I will conduct an online search to determine that all necessary facts and data regarding a topic are available. These websites will be bookmarked for future reference.

2. **Research between journeys and after travel has been completed**

   This time will be used to go to back to the bookmarked sites and to search for other sites to collect necessary information about specific topics.

II. Processing the Information

A. Classroom Presentation Briefs – I plan to prepare presentation briefs for at least one topic in every chapter in all of the courses that I regularly teach: inorganic chemistry (CHEM 10, CHEM 40, CHEM 50 and CHEM 51) and introductory organic and biochemistry (CHEM 20). Many of the topics in CHEM 20 are also covered in the two semester organic sequence (CHEM 80 and CHEM 81). My estimate is that 40 – 50 briefs will be created.

1. Correlate the ideas and topics from the collected information with the material covered in Department courses.

2. Develop each idea or topic to include a historical context, interesting facts, details about noteworthy individuals, pictures, diagrams, available video clips and internet sites.

3. Package the presentation briefs so that they may be easily used by other professors – probably as PowerPoint presentations stored on the Department server and therefore readily available for use on the projection systems installed in the classrooms in the new science buildings.

B. Exhibits for Hallway Display Cases – I will select topics that are visually and scientifically appealing for the new building 7 hallway display cases. The display cases have several inches of depth, so that objects can be placed in front of posters that are pinned to the backing. I anticipate developing at least 12 topics for exhibits.

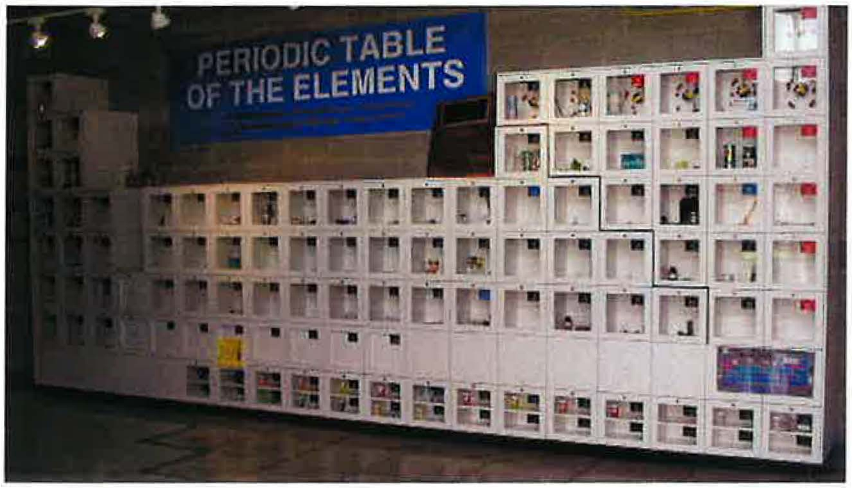
1. Develop a preliminary design for an exhibit that includes a diagram of a layout that indicates the placement of relevant text, pictures and objects.

2. Provide the text and as many of the materials possible for the exhibit.

3. Make a list of any items that need to be acquired by the Department to complete the exhibit.

C. **Exhibits for Natural Science Exploratorium** – I will consult with the Dean and Assistant Dean of Natural Sciences for guidance on appropriate exhibits. As I explore science centers and museums, I will identify existing exhibits that might be recreated at Mt. SAC (with appropriate permission, of course). I will also develop original ideas for exhibits.

Example of possible exhibit for the Natural Science Exploratorium – A "Living Periodic Table" located at the Ruth Patrick Science Education Center at the University of South Carolina Aiken, pictured below. This display would contain physical examples of the elements, either in the pure or compound form and a brief "biography" of the element. A picture or model would serve for elements that are considered dangerous.



TIMELINE

FALL SEMESTER 2008

Aug.	Sept.	Oct.	Nov.	Dec.
Travel to Philadelphia and New York.	Develop topics into presentation briefs. Refresh German skills.	Travel to Bavaria & Austria.	Develop topics into presentation briefs. Internet research.	Review completed briefs. Create list of topics not yet addressed. Plan spring travel.

WINTER SEMESTER 2009

Jan.	Feb.
Take courses. Develop designs and ideas for exhibits.	Take courses. Develop designs and ideas for exhibits.

SPRING SEMESTER 2009

Feb.	Mar.	Apr.	May	June
Take courses. Develop designs and ideas for exhibits.	Complete courses. Internet research.	Travel to venues selected in December.	Develop topics into presentation briefs.	Complete all work.

BENEFITS OF SABBATICAL LEAVE ACTIVITIES

I. Benefits to Me

If I hadn't become a biochemist, I would have majored in history. The obvious benefit of this sabbatical leave is that it will allow me to have the opportunity to meld two of my passions and thus greatly increase my knowledge and teaching resources. I will become a more effective teacher by bringing back that knowledge to be able to create connections (for my students) between the science that is taught inside of the classroom and that of the outside world. Having a full nine month period to immerse myself in science and history would be many times better than winning the lottery!

II. Benefits to Students

As mentioned above, according to the Langford "Quality Learning Course" and the Developmental Education course, students learn better when they are interested in and feel connections to a subject. Students will be able to relate what they learn inside of the classroom to their current personal and future professional lives. My biggest hope is that students who take my classes will learn an appreciation of science that continues throughout their lives!

Students in the Department will benefit by the interesting and informative exhibits in the hallway of the remodeled science building.

III. Benefits to the Department

The presentation briefs will be made available to all Department colleagues (adjunct and full-time). Professors will be able to select from resources that are already developed and organized by topic for inclusion in their classes. This should make it easier for interesting material to be inserted in any course offered by the Department.

The exhibits created for the display cases will be relevant to several courses. For example, CHEM 10, CHEM 40 and CHEM 50 all study the organization of and information contained on the periodic table. A possible topic for an exhibit is the development of the modern periodic table. The display will contain diagrams of early attempts to categorize elements, Mendeleev's version(s) of the first periodic table, a periodic table from each decade in the twentieth century and a modern periodic table with the names of the elements. Students in all three courses could be given assignments related to arrangement of the elements with respect to time, the increase in the number of elements with time, or noting the elements whose names have changed.

IV. Benefits to the Division

The Division will have a list of ideas that can be used to create exhibits for the Exploratorium. The resources in the new Science Building will be fully utilized: the display cases will not sit empty, Materials will be available for use on the state-of-the-art media equipment installed in all classrooms.

V. Benefits to the College

In addition to all of the benefits listed above, it is possible that the information gathered during this sabbatical leave will be assembled into a History of Science course at a later, appropriate date.

BACKGROUND AND STATEMENT OF PURPOSE

Over the last twenty-eight years that I have been teaching chemistry, I have continually been made aware that students do not view chemistry as the fascinating, relevant subject that I do. Many pre-nursing students seem to be convinced that chemistry is required to function as a barrier placed in their path as a means to eliminate those deemed less worthy of pursuing the profession of nursing. They do not see the applicability of chemistry to any aspect of their future careers or lives. Science majors at Mt. SAC frequently see chemistry as a necessary evil filled with facts and formulas that must be memorized as the course is endured on the way to their chosen major, usually biology. When new acquaintances find out that I am a chemistry teacher, the majority have a horror story to relate about their experience in their chemistry courses. It is rare that someone will relate that chemistry was an exciting course for them or they use something that they learned in chemistry class on a daily basis. I have come to feel that it is as important to expose students to the beauty and significance of chemistry as it is to teach the basic information of the courses!

As a science major myself, my schedule was filled with elective science courses such as virology and mycology at the expense of humanities. The one required philosophy course that I took seemed to be a colossal waste of time. Attendance was not required. The curriculum included a serious discussion comparing the value of a pet rock (yes, this was in the 70's!) to a live pet. Much time was spent determining how I knew that I existed! I did not find the subject interesting or compelling – much like my students view chemistry. There was no connection established between science and philosophy by either department.

As I endeavor to improve my teaching, I recognize the importance of establishing connections between science, philosophy and history as a means of making chemistry interesting and relevant to students. This goal was addressed in the original statement of purpose in my sabbatical proposal, "*I have reached a pivotal point in my teaching career. I have set a new goal: to enhance every topic in a manner similar to the example of nuclear chemistry. Students who are stimulated to understand and embrace the relevance of science will attain far more lasting benefits from their education than those who simply memorize material for the next exam. The prohibitive factor is finding the time necessary to research and prepare the resources/supplemental items needed to incorporate historical and pertinent connections into every course that I teach. I have achieved a high level of expertise in the field of chemistry, but there are entire areas (History of Science and Philosophy of Science, for* *example) to which I have had very little exposure. A two semester sabbatical leave will provide the time necessary to acquire and organize the body of knowledge needed to enhance my classroom presentations.*"

The purpose of my sabbatical leave was to provide the opportunity for me to gain expertise in the areas of the history and philosophy of science. In addition, the time free from teaching responsibilities was to allow me time to develop materials that will enhance classroom presentations.

This proposal has four major goals and a myriad of activities to be undertaken to accomplish these goals. The goals are:

1. Compile a compendium of selected significant scientific events/breakthroughs relevant to Mt. SAC science courses.
2. Prepare "presentation briefs" to enhance classroom lectures and stimulate student interest.
3. Develop ideas for exhibits to be mounted in the Chemistry Department display cases.
4. Compile an inventory of possible exhibits to be mounted in the Natural Science Exploratorium.

The activities include traveling to historic sites and to museums, taking courses in the History and/or Philosophy of science and conducting research using online and print resources.

This report recaps a chronological list of sabbatical activities with a description of the activity, including a description of how the four goals were accomplished using the information from the activities.

I. Chronology of Sabbatical Activities

A. July 2008 – Travel to Biennial Conference on Chemical Education Bloomington Indiana

The first activity on my sabbatical leave was a trip to the Biennial Conference on Chemical Education (BCCE) in Bloomington, Indiana. This was a change from the original proposal. The original intention was to travel to Philadelphia to attend the American Chemical Society fall national meeting in August, 2008. Visits to the Chemical Heritage Foundation in Philadelphia and several museums in New York were to be included on the trip to the east coast. After my proposal was accepted I became aware that the BCCE would held in July 2008. During the year when the BCCE is held (usually in July) the fall American Chemical Society (ACS) meeting follows within a month of the BCCE. Most educators do not attend both meetings and a majority chooses to attend the BCCE. As a result, the ACS meeting has reduced resources for educators. I requested permission to delay my east coast visit until the spring and attend the BCCE instead (see Appendix A). During the BCCE meeting the following workshops and activities that were relevant to sabbatical activities were attended.

1. The following two workshops provided ideas for exhibits for the Natural Science Exploratorium and Chemistry Department display cases.

W13 A Carousel of Discrepant Events *"Each of the presenters will select two demonstrations from the hundreds of experiments published in Tik Liem's book, INVITATIONS to SCIENTIFIC INQUIRY. Participants in this session will move through the CAROUSEL, take part in each of the DISCREPANT EVENTS and have ample opportunity to talk to each of the presenters. The CAROUSEL will continue "rotating" for the duration of the session. Each of the events will be repeated four times. Be prepared to enjoy, learn, observe, hypothesize, predict, question, and take home a number of exciting activities for use in your classroom."* [1]

W55 Chemistry of Art in the Laboratory "*The half- day workshop will consist of 4 or 5 lab activities facilitated by facilitators and alumni of the CWCS Chemistry of Art workshop. Activities will include: analysis of coins using a homebuilt paramagnetic apparatus; analysis of paints and pigments by reflectance spectroscopy; modifying the surface of metals; preparing and comparing cyanotypes and diazo blueprints. The activities are appropriate for use in general education lab science courses for non-science majors as well as in general, organic and analytical chemistry courses for science majors. The CWCS is supported by NSF, DUE, CCLI Program (DUE-0618678)*" [1]

2. As mentioned in the original proposal, I have implemented innovative teaching techniques over the course of my career; computer-assisted, student centered learning with the Molecular Science Initiative, Langford and techniques learned in the Development Education course. During this conference, I attended POGIL training. This teaching method is based on the scientific method of inquiry, developed as science transitioned from "Natural Philosophy" into modern disciplines, during the Scientific Revolution in the eighteenth century.

W2 Introduction to POGIL "*This workshop will introduce the principles of POGIL - Process Oriented Guided Inquiry Learning. Participants will experience a POGIL classroom from a student's* *perspective, analyze a POGIL activity, and learn about the pedagogic basis for POGIL. Information about the effectiveness of the approach in a variety of settings will also be presented".* [1]

W29 Advanced POGIL Workshop: Using and Designing POGIL Laboratory *"In many traditional laboratory settings, a concept that has been previously introduced in class, or presented as part of the pre-lab preparation, is confirmed through the "experiment". In a POGIL laboratory experience, however, a chemical concept is developed based on data collected in the laboratory. Students work in teams and gather data from experiments run under a variety of conditions. They use a set of in-lab and post-lab guided inquiry questions to examine the pooled data (from their own lab section and often from other lab sections) from which they construct theories to explain experimental results. This workshop will include a discussion of the criteria for successful POGIL laboratory experiments, examine model experiments, work with student- generated data in a simulated laboratory setting, and convert existing and currently-used lab activities to POGIL experiments. Workshop participants should bring copies of lab activities for conversion to POGIL experiments. Participants in this workshop are expected to have attended the "Introduction to POGIL" workshop at this meeting, or have equivalent prior experience and knowledge of POGIL (http://www.pogil.org)."* [1]

3. **Trip to the Wonderland Science Museum** – Bloomington, Indiana

The Wonderland Science Museum is a children's hands-on science museum. The museum was reserved for attendees of the BCCE, allowing the adults to freely experience the exhibits without the self-consciousness that occurs when children are present. The museum provided many innovative ideas that would be appropriate for the Natural Science Division Exploratorium. The names of the builders of the exhibits, The Whitaker Center and Hoffman Design Works, were noted so that information could be obtained regarding the purchase or construction of materials for the Natural Science Exploratorium.

4. **Chemical Heritage Foundation booth at the Exposition.**

I spent a significant amount of time with the representative from the Chemical Heritage Foundation (CHF). He provided two books – Chemical Achievers and Pharmaceutical Achievers and several pamphlets regarding the resources available at CHF. He also explained how to make the most efficient use of my future visit to CHF and gave me contact information for research assistance.

B. August 2008

1. **Exhibits for the Natural Science Exploratorium**

A list of possible exhibits for the Natural Science Exploratorium was prepared, based on ideas from the Biennial Conference on Chemical Education. Displays and exhibits that seemed appropriate were selected from those seen at the Wonderland Science Museum. Websites were located for The Whitaker Center and Hoffman Design Works, Inc., manufacturers of many of the displays.[2, 3] The websites contained specifications and contact information for purchasing the finished products. This information was assimilated (see Appendix B) and presented to Larry Redinger, Dean of Natural Sciences.

C. September 2008

1. **Compendium**

The month of September (2008) was spent performing online research regarding historical science and technology events. At the beginning of this project, compiling the compendium seemed to be a daunting task. One of the first skills that I set out to acquire was how to conduct efficient and effective research on the internet. Prior to beginning the upcoming Science Tour of Germany and Austria, I searched for a "skeleton' timeline of historical science and technology events that could be developed over the course of the year. I began to focus on the final form of the compendium – what did I really want to achieve when the compilation of information was complete?

After a week of searching and reviewing websites, I eventually selected a science timeline "*Marks in the Evolution of Western Thinking about Nature*", by David Lee[4] that served my purposes. The author best explains his creation:

"*Despite the title tag 'science timeline,' this is not meant to include all science, that is to say all knowledge, rather just the knowledge which people have accumulated--in the West--about the things over which they have, as yet, little control. This is the 'nature' to which I refer. It includes the traditional 'exact' sciences, mathematics, and the philosophy of science and it excludes art and society and the thinking about many other things. On the other hand, new layers of consciousness, for example, certain moments in the creation of representational and abstract painting and of historical writing, are included as important marks in the evolution of thinking about nature.*"[4]

This timeline begins at 10,000 BC with the domestication of wolves and outlines the development of technology and civilization up to the end of the twentieth century. Even though the author had targeted knowledge accumulated in the West about nature, he has included a significant amount of information contributed from the East. The website is interactive and downloadable. It is possible to select relevant items for downloading and printing. I decided to download the entire timeline as a starting point for my compendium. Instead of beginning the compilation with an empty palette, I had an overabundance of information from which I could select the relevant items and delete the extraneous.

The next challenge was to decide how to organize and edit the material contained in the timeline for study. This exercise by itself proved to be very enlightening. I began by dividing the information into eras, which proved to be both challenging and informative. Dividing the material after 1 AD by centuries produced a visually remarkable result. The early centuries contain barely a page of significant events each. The list for the sixteenth century was three pages long, but the seventeenth century was ten pages. The eighteenth century was fourteen pages and the nineteenth century was thirty-five pages. Beginning with the seventeenth century, the material was divided into decades. The result was the production of a document that had interesting, manageable sections of information. The entire edited timeline was approximately 150 pages long (see Appendix C for selected pages of the Compendium). Many hours were spent reading and reviewing the compendium as preparation for the Science Study tour in Europe.

D. October 2008 – Science Tour to Germany and Austria.

Armed with 150 pages of information regarding historic science and technology events and a rudimentary knowledge of the German language, I ventured to Europe.

1. **Opel Automobile Factory and Museum Tour – Rüsselsheim, Germany**

Adam Opel founded a sewing machine factory in 1862. Opel added bicycle production in 1886 and automobiles in 1902 (see photo of museum, below left). The factory burned down in 1911. The plant that was rebuilt in 1912 was the first German assembly line to produce automobiles (see photo below, right). It was recently remodeled and is one of the most technologically advanced in the world.

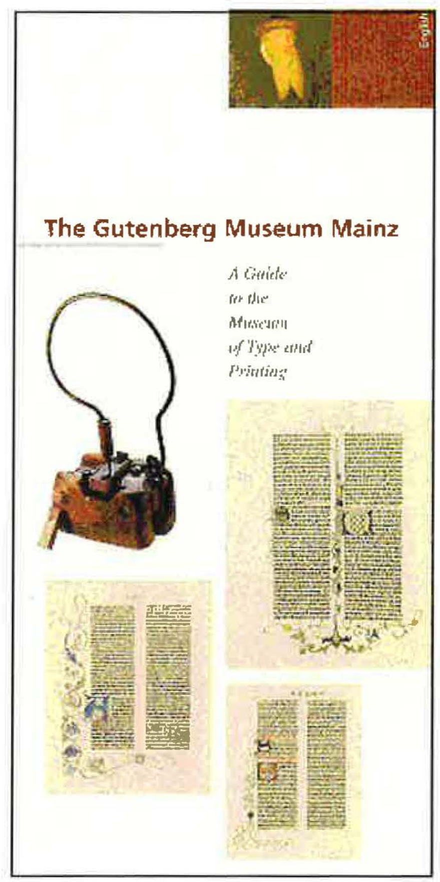
The invention of the sewing machine, bicycle and engines that use fossil fuels were part of the nineteenth century industrial revolution. As an American, I am aware of the story of Henry Ford. It was very interesting to see part of the story of the history of the automobile from a European perspective.

Opel sewing machines and bicycles.

An Opel automobile circa 1900.

2. **Gutenberg Museum – Mainz, Germany**

One of the most significant factors contributing to the explosion of literacy and the scientific revolution that occurred in Europe was the invention of the printing press around 1437. Gutenberg was a native of Mainz. This museum contains a reconstruction of his work room including a printing press. Demonstrations are given that include a detailed explanation of the process that was used to set and print a page.



The museum chronicles the history of printing, from the invention of the printing press through the 20th century. It also includes many samples of printing from cultures all over the world, including China, Japan and Korea that predate Gutenberg's invention. The centerpieces of the collection are two Gutenberg Bibles.

3. **Leinreiter Monument – Main River Bank, Russelsheim, Germany**

This monument along the bank of the Main River in Russelsheim commemorates the "rope riders" who provide power to barges carrying commodities to market in Frankfurt prior to the invention of the steam ship (photo on left, below). These boats could navigate under their own power to Darmstadt, using the downstream current and wind. To get to Frankfurt from that point required sailing against the current, impossible for the early market barges. To complete the journey to Frankfurt, a rope from the boat was attached to a draft horse. The rope rider would guide the horse along the shore as it towed the boat the remaining distance to Frankfurt.

The remarkable thing about the placement of the statue is the background; large storage tanks of petroleum visible across the river. Barges ferrying commodities to market still travel along the Main River to Frankfurt, but with a different, more modern source of energy.

Leinreiter monument – Russelsheim.

Fortress circa 1620 – Russelsheim.

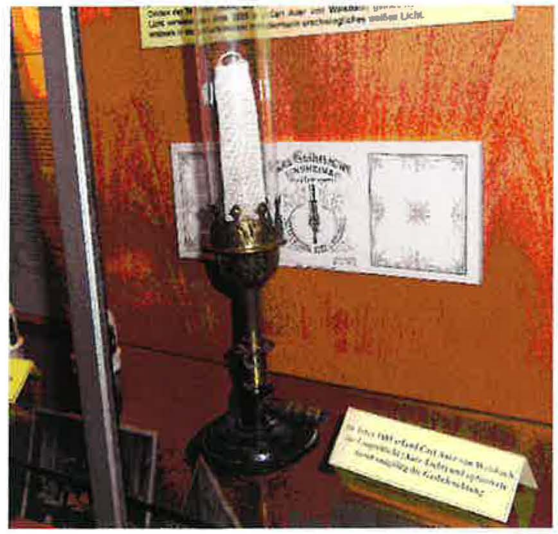
4. **Fortress From The 30 Year War – Bank of Main River, Russelsheim, Germany**

Forts dating to the 30-Years War (1618–1648) dot the banks of the rivers of Germany (photo on right, above). The conflict that began as a religious discord evolved into an event that realigned the borders of nations and affected the astronomers of the time.

5. **Von Welsbach Museum – Althofen, Austria**

Carl Auer Von Welsbach (1858-1929) was an Austrian chemist who performed basic scientific research and successfully commercialized some of his discoveries. As a graduate student, he studied in the laboratory of Robert Bunsen, of Bunsen burner fame. He is credited with discovering four elements: Neodymium (Nd), Praseodymium (Pr) (photo of crystal, left below), Ytterbium (Yb), and Lutetium (Lu). He invented the gas mantle, which is fitted on top of a burner to increase the amount of light provided. He also invented the lighter flint that is still used in lighters today, and the metal wire inside of incandescent light bulbs. The museum houses many artifacts of his research as well as his original laboratory. One of his early lamps with the gas mantle appears to be a Bunsen burner that could be found in a chemistry laboratory today (photo on right, below).

Crystal of Praseodymeum.



Original Bunsen burner, fitted with mantle.

6. **Knappenberg Mining Museum – Hüttenberg, Austria**

Iron mining at this site is first mentioned in 500 BC. During the Roman Empire, the iron mine at this location was famous under the name "Ferrum Noricum. The last working mine closed in 1978, but the mine is now available for tours that demonstrate mining techniques from the early and mid twentieth century (see photo below, left). The accompanying mineral museum contains examples of some minerals that are rarely found anywhere else (see photo below, right). The tour includes a furnace used for smelting ore in Roman times that was excavated from local ruins.

Inside of the Knappenberg mine.

Mineral unique to Hüttenberg, Austria.

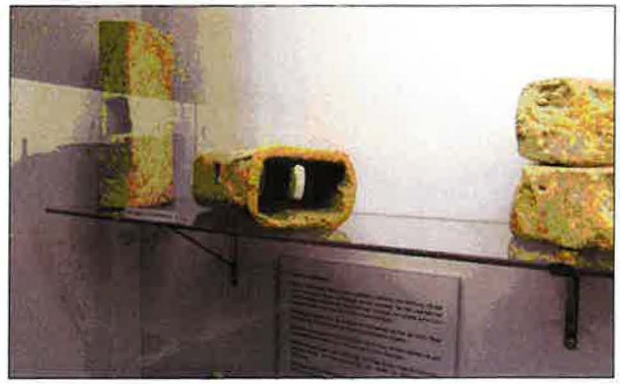
7. **Hüttenberg iron mine and Heft Blast Furnace – Hüttenberg, Austria**

Nearby in the village of Heft, are the remnants of nineteenth-century blasting furnaces that were used to process the locally mined iron ore. This structure, used to manufacture steel from iron, was established during the Industrial Revolution.

Heft Blast Furnace - Hüttenberg, Austria.

8. **Roman Ruins – Magdalensberg, Austria**

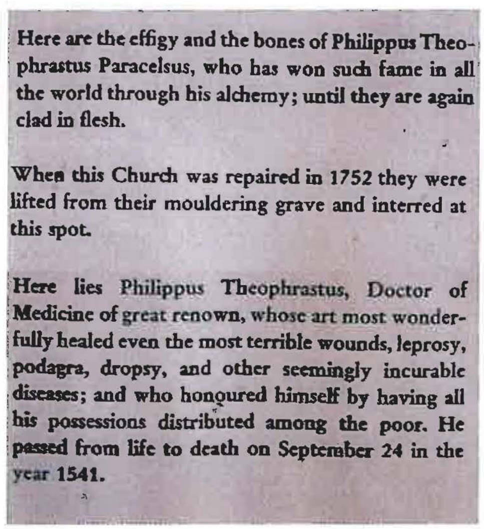
The Roman ruins (photo, below left) date back to the site of a Celtic copper mine. Around the first century AD, the Romans invaded. They assimilated into the Celtic settlement, rather than conquering it. Examples of Roman technology are displayed, including ceramic pipes used transport steam to heat floors (see photo, below right).



Roman Ruins – Magdalensberg, Austria. Hollow Roman tiles used to transport steam.

9. **Paracelsus Grave – Salzburg, Austria**

One of the first European alchemists was Philippus Aureolus Paracelsus (1493–1541). He rejected some of the occultism that had accumulated over the years. He promoted the use of observations and experiments to learn about the human body and pioneered the use of chemicals and minerals in medicine. His grave is in St. Sebastiansfriedhof, a cemetery in Salzburg, near the grave of Wolfgang Mozart's widow (see photos, below).



Here are the effigy and the bones of Philippus Theophrastus Paracelsus, who has won such fame in all the world through his alchemy; until they are again clad in flesh.

When this Church was repaired in 1752 they were lifted from their mouldering grave and interred at this spot.

Here lies Philippus Theophrastus, Doctor of Medicine of great renown, whose art most wonderfully healed even the most terrible wounds, leprosy, podagra, dropsy, and other seemingly incurable diseases; and who honoured himself by having all his possessions distributed among the poor. He passed from life to death on September 24 in the year 1541.

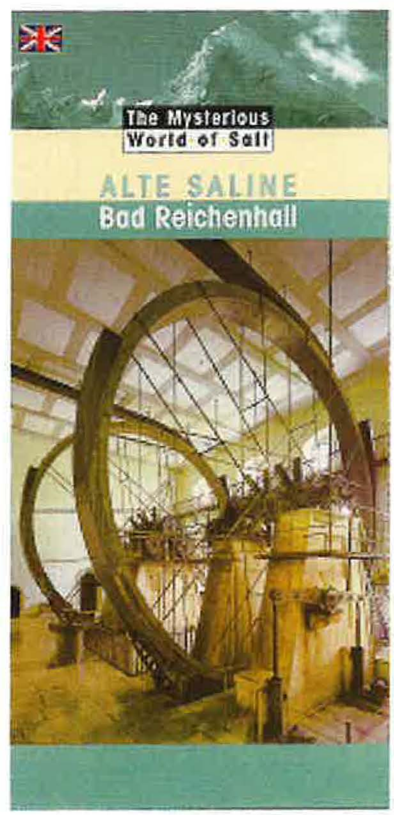
Site of Paracelsus grave. Text on grave marker. Grave of Mozart's widow.

10. **Salzbergwerke – Berchtesgaden, Austria**

This is the site of the Salzbergwerke, one of the numerous salt mines still working in the region surrounding Salzburg. We traveled into the mine aboard a mini-train after putting on worker's overalls. The tour included information about all phases of 15th century salt mining, including a miner's slide down to the lower levels and an underground brine lake.

11. **Alte Saline – Bad Reichenhall, Austria**

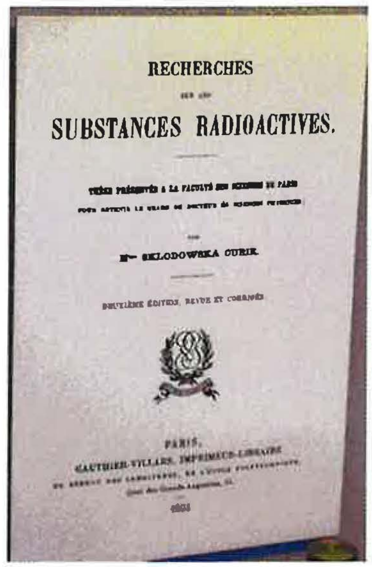
The traditional center of salt production both from the Salzbergwerke and from local salt ponds and springs. We toured the Alte Saline (old salt refinery) and saw the engineering feats that supported salt production from the sixteenth century. Also included in the tour was the Salt Museum which displays equipment and dioramas that detail how salt was harvest and purified for market.



12. **Deutsches Museum – Munich, Germany**

This museum contained an amazing section on chemistry, including many artifacts of significant European scientists such as one of Robert Bunsen's original burners (see photo, below left) and a replica of the cover page of Marie Curie's dissertation (see photo, below center). One gallery contains a recreation of Antoine Lavoisier's laboratory (see photo, below right). Another contains the first diesel engine, patented by Rudolf Diesel in 1892. The museum also contains a "Sundial Garden" on the roof and a "Do-it-Yourself" sundial in the courtyard.

An original Bunsen burner.



Marie Curie's dissertation Cover page.

Recreation of Lavoisier's Laboratory.

E. November/December 2008

This time period was spent assimilating the information that was collected during the previous month as well as performing online research. Two major tasks were undertaken during this time interval; (1) designing the format and creating a list of topics for the "Classroom Presentation Briefs" and experimenting with displays for the Chemistry Department display cases. More ideas for Exploratorium exhibits were also developed.

1. **Classroom Presentation Briefs (aka "Vignettes")**

The "Classroom Presentation Briefs" were rechristened "Vignettes". A CHEM 10 syllabus was used to select topics. It seemed logical to begin at the beginning, so the first vignette planned was on the topic of the origins of Chemistry. The search for information to be included in the vignettes was carried out primarily on the internet. This proved to be a daunting task. Entering the phrase "Origins of Chemistry" into a search engine produced over 67 million results! It became necessary to develop a process for refining searches to yield useful information. Since it is well known that much information on the internet is not accurate, all facts that were included were verified by three reliable sources. Frequently, identical information was available on many websites, so it became challenging to determine where information originated and what a "reliable resource" was. Wikipedia proved to be an excellent starting point. It provided a comprehensive outline from which links could be selected. The trip to Europe and the material for the HSTS course I was taking also provided information.

I was able to focus on the history of the topic "Alchemy" and the transition of Alchemy into "modern chemistry" that occurred in the eighteenth century in Europe. Wikipedia also provided links to websites on very specific related subject matter. Images included in the vignettes were my personal photos or taken from the public domain whenever possible. The artist or photographer, if known, is noted near an image.

It took approximately two weeks to complete a satisfactory rough draft of the vignette titled "Chemistry" (see Appendix D for printout of the PowerPoint). Since the format for the vignettes was a PowerPoint presentation, it was important to limit the amount of information on a slide. With the plethora of information available, the challenge was to tell an interesting story while being discerning with the material that was included. References used in the development of a vignette are listed at the end of the PowerPoint presentation.

Once a research method and format was established and the vignette on "Chemistry" was piloted, the CHEM 10 syllabus was reviewed to choose the next topics to develop. The three topics below were chosen because they occur relatively early in the semester.

How Cold Was It?

Chemistry with a Bang

The Periodic Table

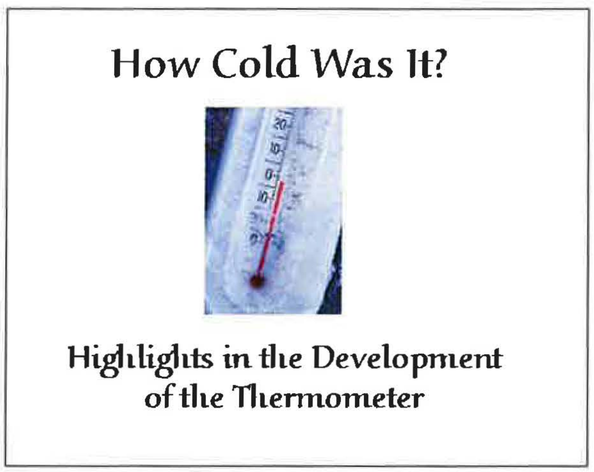
As I researched "Chemistry" I became acquainted with some very interesting individuals. It became obvious that two types of vignettes could be developed: topical and biographical. For example, as I worked on the vignette on the periodic table, I became very interested in the life of Dmitri Mendeleev (see Appendix E for a printout of the PowerPoint). It didn't seem feasible to develop an in-depth presentation on Mendeleev in the vignette of the period table. I chose two individuals to develop into biographical vignettes during this time period:

Agnes Pockles

Dmitri Mendeleev

2. **Exhibits for Hallway Display Cases**

The winter intersession seemed like the perfect opportunity to begin experimenting with exhibits for the Chemistry Department display cases. The slides of the PowerPoint vignette titled "How Cold Was It?" were printed and posted in the building 60 display case during the first week. The display consisted of nine slides highlighting the development of the thermometer and included a Galileo thermometer placed in front of the display. The design of the slides was effective: the illustrations were eye-catching and the font could easily be read while standing a comfortable distance from the display case. Printouts of five more completed vignettes were posted weekly in the display case, one each week of the winter intersession.



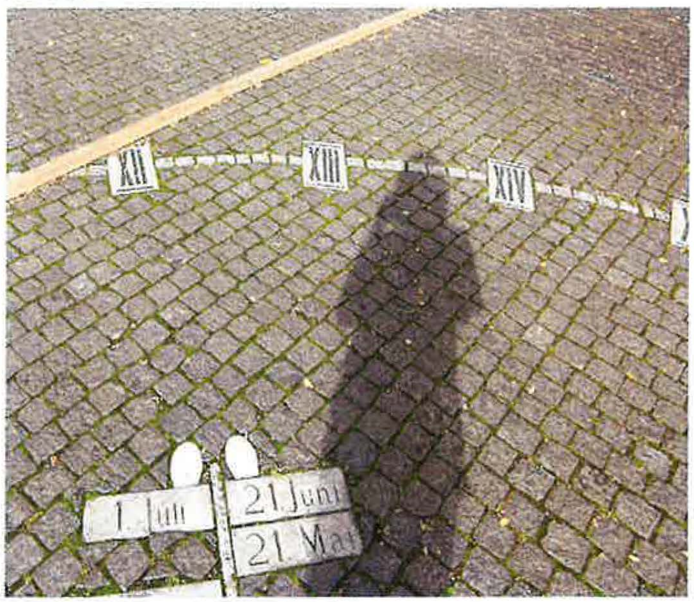
Title slide for "How Cold Was it?" vignette

"How Cold Was It" mounted in a hallway display case.

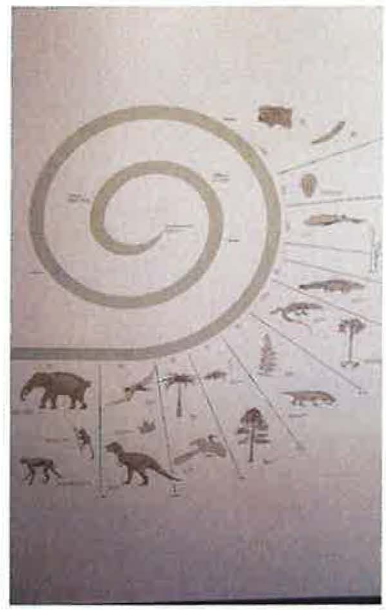
3. **Exhibits for Exploratorium**

Prior to the trip to Europe, Larry Redinger had requested ideas for sundials as exhibits for the new science complex. As I traveled through Germany and Austria, I photographed all types of sundials. In fact, I had never realized that there were so many types of sundials! The most interesting one was the human do-it-yourself sundial in courtyard of the Deutsches Museum in Munich (see photo, below left).

Another idea for an exhibit that evolved during the trip to Europe was an illustrated timeline demarking significant events in the sciences represented by the departments in the Natural Sciences Division. The initial idea came from the parking garage at the Frankfurt International airport. We found our car by following the timeline on the wall to "Cleopatra". This was more interesting the searching for something like "B2". The timeline was chronologically correct and therefore education, even though it was heavily commercialized; Genghis Khan driving a Mercedes! The Deutsches Museum had a timeline on the evolution of life on earth (see photo, below right). Pictures of sundials (see Appendix B) and the idea for an interdepartmental timeline were presented to Larry Redinger and Matt Judd.



"Human" sundial at Deutsches Museum.



Timeline of life on earth.

F. January/ February/ March, 2009

1. **Coursework**

a. **Changes to Proposal**

The intent was to select three courses from the list initially submitted as part of the proposal, to be taken during winter and spring quarters. This turned out to be impossible, partially due to budget issues in California. The courses would be taken through the Extended University. As classes and sections were cut during the fall, the courses I wanted to take were full. I would not be able to register unless there was an opening during the first week of classes, and I would have a very low registration priority. This made it unlikely that I would be able to complete the coursework at local institutions.

A course equivalent to UCLA's History 3A (Introduction to History of Science: Scientific Revolution) was found at Oregon State University; HSTS 411. The course was a 4-unit upper division online offered during the winter 09 quarter. I was apprehensive about the rigor of instruction in an online course. I enrolled in the course to see if it would be an appropriate substitute. After two assignments, I was pleasantly surprised to find that the course actually exceeded my educational expectations! Permission was requested and granted to substitute HSTS 411 and the subsequent course, HSTS 412 (offered spring 09 quarter) for two of the local courses included in my proposal (see Appendix A).

b. **HSTS 411 HISTORY OF SCIENCE (4)**

"Stresses the interaction of scientific ideas within their social and cultural contexts. Scientific thought from ancient civilizations to the post-Roman era.
PREREQS: *Upper-division standing; at least one science sequence."* [5]

See Appendix G for Syllabus and Appendix I for final grade.

HSTS 411 began the first week of January and ended in March. The course work consisted of readings from four texts, a weekly written homework assignment, two midterms and a final. Approximately 15 to 20 hours per week were spent on this course.

c. **Proposal For Self Study**

As I pursued my coursework and conducted research for vignettes, I became fascinated with individual scientists (as mentioned above). I had studied Agnes, Pockels, a nineteenth century German scientist who had no post secondary education and performed all of her research in her home. After being refused lab space at a German university because she was a woman, she had her work published in the prestigious journal "Nature". As I searched for a third course to satisfy that activity, I recognized that most available courses contained significant overlap with HSTS 411 and HSTS 412. I requested and was granted permission (see Appendix A) to research five historically interesting and inspirational scientists to satisfy the requirement for the third course. The following scientists were selected:

Arnold Beckman

Benjamin Franklin

Benjamin Rush

Alfred Nobel

George Washington Carver

2. **Travel**

   a. **Museum of Nuclear Testing – Las Vegas, Nevada**

   This museum was not on the original list of sites to visit, because I was unaware of its existence. This museum chronicles the continued pursuit of nuclear weapons after World War II, the Nevada Test Site testing program and the testing of hydrogen bombs in the South Pacific. Two new elements were discovered from the material collected on filters suspended from aircraft flown through the atmosphere after a test detonation of a thermonuclear device.

   b. **New York Hall of Science – Flushing, New York**

   This is a hands-on children's science museum. The exhibit titled "Marvelous Molecules" was appropriately titled! The relatively simple displays of models of molecules with brief descriptions proved the saying "a picture is worth a thousand words." Displays like these could easily be mounted in either the Department display cases or the Natural Science Exploratorium.

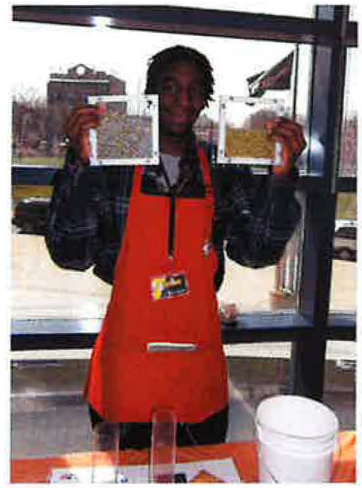
Model of antigen & antibody.

Model of digitalis molecule.

Model of DNA.

This museum included demonstration areas that were staffed by high-school aged personnel. The young gentleman pictured (below, right) presented a demonstration of how nanotechnology could be used to design a baseball bat that can hit a ball farther than a traditional bat. The young lady (below, left) used dry ice and balloons to demonstrate the phases of matter.

Demonstration of states of matter.



Nanotechnology demo.

c. **American Museum of Natural History – Manhattan, New York**

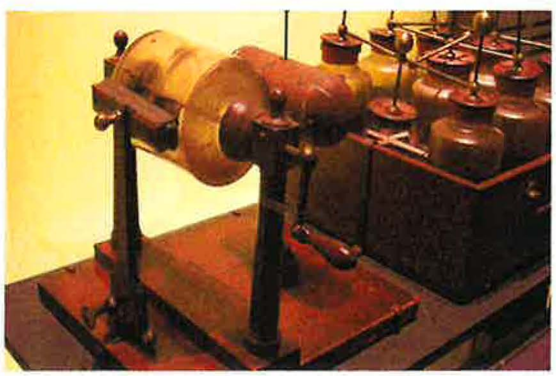
The highlight of the visit to the American Museum of Natural History was the Mineral Hall. There is a lot of material that will be useful for CHEM 51, where transition metals are studied. The minerals were mounted from a chemist's perspective, in related groups that were highlighted on an accompanying periodic table. Exhibits similar to this might be possible in the Natural Science Exploratorium with the cooperation of the Geology and Chemistry Departments.

Mineral displays correlated to the periodic table.

d. **Chemical Heritage Foundation (CHF) – Philadelphia, Pennsylvania**

The advice from the Chemical Heritage Foundation representation at the Biennial Conference on Chemical Education was followed. A research librarian at the Chemical Heritage Foundation was contacted before my visit and specific information on the individuals selected for my self study course was requested. When I arrived, resources had been assembled for me. My three-day visit was very efficiently spent reviewing the resources. A significant amount of information was gathered about Benjamin Rush, Alfred Nobel, and Avicenna. I was able to obtain a photocopy of the first chemistry text published in America, authored by Benjamin Rush.

The lower level of the CHF building contains a museum displaying scientific instruments and apparatus, rare books, fine art, and the personal papers of prominent scientists. Topics range from alchemy, synthetics, and the chemical-instrument revolution to chemistry education, electrochemistry, chemistry sets, and the science of color. Some of the original equipment used by Benjamin Franklin to generate electricity (see photo, below left) and developed by Robert Bunsen (see photo, below right) is displayed.



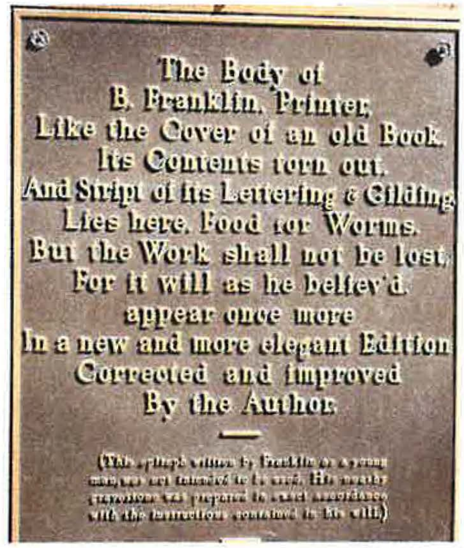
Ben Franklin's electricity generator.

Robert Bunsen's thermostat.

e. **Christ Church Cemetery – Philadelphia, Pennsylvania**

The Christ Church cemetery is the final resting place of four signers of the Declaration of Independence, including two of America's first scientists: Benjamin Franklin and Benjamin Rush (see photos, below).

Grave of Benjamin Rush



Grave marker of Benjamin Franklin

3. **Classroom Presentation Briefs (aka "Vignettes")**

During this time, I continued to develop vignettes.

G. April 2009

1. **Course Work – HSTS 412. HISTORY OF SCIENCE (4).**

"*Stresses the interaction of scientific ideas within their social and cultural context. Origin of modern science in the 16th and 17th centuries.*

PREREQS: Upper-division standing and at least one science sequence."[5]

See Appendix H for syllabus and Appendix I for final grade.

2. **Self study**

The development of vignettes of the five scientists selected for self study was continued.

3. **Travel – Balboa Park; San Diego, California**

As I paused to reflect on where I had visited and what I still wished to achieve, I reviewed the list of possible venues. The museums in Balboa Park, San Diego were selected based on two special exhibits that were on display: Body Worlds in the Natural History Museum and the DaVinci Exhibit in the Aviation Museum. In addition the Ruben H Fleet Museum was visited, since it is also located in Balboa Park.

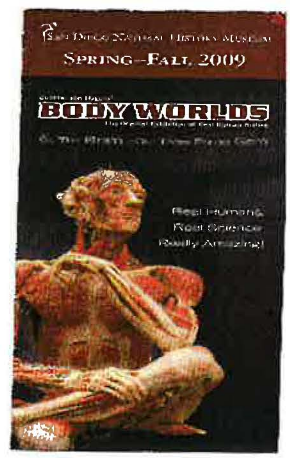
a. **Ruben H. Fleet Museum** – a hands-on children's science museum.

This museum contained very interesting visual wall art (see photos, below). The photo on the left is a three-dimensional rendering of a polio virus.

Display on the life of Edwin Hubble.

Three-dimensional picture of a polio virus.

b. **San Diego Natural History Museum – BodyWorlds Exhibit**



This exhibit is mesmerizing! It displays human bodies dissected so that the entire anatomy can be seen. The bodies have been plasticized for preservation. The exhibit is grotesque, beautiful and intriguing! It is a must-see for anyone who is interested in human anatomy.

c. **Aviation Museum – DaVinci Exhibit**

This was a phenomenal exhibit where scale models were built of some of Leonardo DaVinci's ideas. The exhibit included a timeline of the history of the time juxtaposed on DaVinci's life. I found DaVinci's "night clock" (see photo, below left) very interesting, including the process by which he searched for the correct wick and candle wax to control the burn rate so that the candle consistently burned the designated distance in the specified time. It was remarkable to see DaVinci's drawings (see photo below, right) of the musculature of a human arm after viewing the BodyWorlds exhibit. DaVinci lived at a time when human dissection was not encouraged.

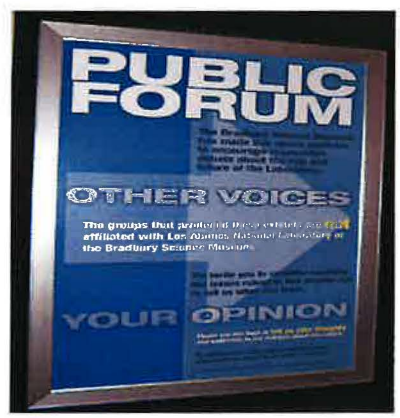
DaVinci's "night clock". Drawings of musculature of human arm.

H. May 2009

1. **Travel**

a. **Bradbury Nuclear Museum – Los Alamos, New Mexico**

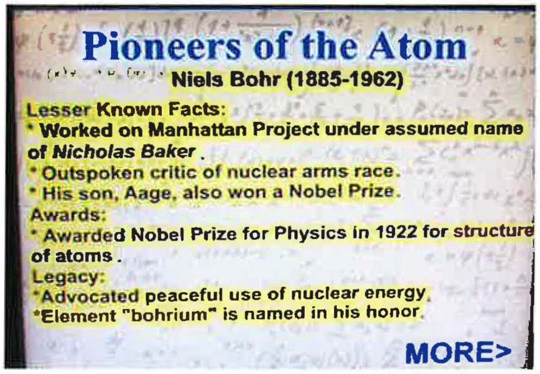
This museum chronicles the years of the Manhattan project, detailing what life was like during this tumultuous time in America's history (see photo below, left). It contained many artifacts of the time, as well as how the direction of research has evolved over the past sixty years. One gallery presented a Public Forum, which allowed recognized groups to mount exhibits with opposing views on controversial topics (see photo below, right)



Display depicting workers at Los Alamos. Room dedicated to "Public Forum".

b. **National Museum of Nuclear Science and History – Albuquerque, New Mexico**

This museum contained a terrific, interactive display of the timeline of the nuclear era. Details of prominent scientists were included (see photo below, left). It contained many examples of nuclear science in popular culture (see photo below, right).



Interactive display of nuclear scientists.

Homer Simpson with safety gear.

I. June 2009

1. Travel - Arnold Beckman Museum, Fullerton

The Arnold Beckman Museum is located in the Beckman Coulter building that is currently being phased out as the company modernizes. The museum chronicles an American success story: Arnold Beckman's journey from a farming community in Illinois to the founder of a corporation that is a leading provider of instrument systems and complementary products that simplify and automate laboratory processes for life science research and clinical diagnostics. During his amazing career, he developed in conjunction with Linus Pauling, an oxygen analyzer (see photo below, left) needed to monitor the air of submarines during World War II. His company also constructed pieces of scientific equipment for America's space program (see photo below, right).

Pauling-Beckman oxygen analyzer.

Carbon dioxide sensor.

J. July 2009

1. Travel– Glacier Bay, Alaksa

This venue was not included in the original proposal. It was actually part of my vacation, but when I saw the blue color, it became obvious that there was a science lesson trying to escape!

Conclusion:

I want to thank the Sabbatical Committee for granting me the opportunity to experience this incredible year! Over the course of my sabbatical leave (July 2008 to July 2009) I achieved all of the goals that I had established. A compendium of selected significant scientific events/breakthroughs relevant to Mt. SAC science courses was compiled, edited and organized. The final product was approximately 150 pages of what proved to be very interesting reading! Even though it was just bullets of information, I thoroughly enjoyed curling up on the couch and reading through three or four pages at a time, trying to picture what was happening historically and what life was like at the time.

Two online History of Science courses were successfully completed. These courses made the material in the compendium I had been reading come to life. The events connoted in the black and white bullets of the compendium transitioned into amazing events, people, places and stories with rich historical contexts. Becoming a student was challenging, especially a distance learning student! The experience reinforced the amount of time required to complete the work required for a college-level course. These two courses went a long way to filling my educational deficiency regarding philosophy. Even though the courses required a considerable amount of time, the reading was fascinating. I actually enjoyed the writing – looking at it as a way to show off my new-found knowledge! I now have an immense appreciation of how the sciences that I know today are built upon centuries of contributions of individuals and societies who asked questions and sought to make improvements to people's lives.

I completed the course of self study, selecting five scientists whose lives I found compelling. Biographical vignettes have been developed for these five individuals. Benjamin Franklin's life was so complex that he warranted two vignettes – one on his life as America's first scientist and a second on his work with electricity.

Overall, I completed thirty-six vignettes (see list below). I had anticipated creating forty to fifty. As I completed the vignettes, I went on to begin new ones and did not allow time for editing. Some of these vignettes are too long and can be edited into two PowerPoints. As I implement these vignettes into my classes this semester, I will be doing this editing. By the end of this semester I anticipate that I will have forty completed vignettes ready to install on the Chemistry Department server for all instructors to use.

Alchemy
Cis-Trans molecules
Ancient Elements
Who Discovered Elements
Energy
Biofuels
Diesel
Octane Rating
Gunpowder
Fireworks
Hot Air Balloons
Oxygen Meters
History of the Periodic table
Berkeley History Lesson
Mendeleev Bio
History of Length
How Cold Was It
History of Mass
Milestones
How Are Elements Named
Elements Named for People
Elements Named for Places
Manhattan Project
Polarity
Redox
Agnes Pockles Bio
Alfred Nobel Bio
Arnold Beckman Bio
Benjamn Franklin Bio
Benjamin Franklin
Electricity
Darwin Bio
Del Rios Bio
GW Carver Bio
Von WelsbachBio
Robert Bunsen
Timeline of elements

Beginning with the 2009 winter intersession, exhibits were mounted weekly in the Chemistry Department display cases. This activity was continued through the spring 2009 semester, with the exhibits being changed every two weeks. Some of the exhibits were printouts of the vignettes, others included interesting objects with the printouts. A list of ten exhibits to be developed, including designs and needed materials, will be presented to the Department at a meeting this semester.

Two detailed lists of designs for possible exhibits for the Natural Science Exploratorium have already been submitted to Larry Redinger; one based on exhibits at the Wonderland Museum in Bloomington, Indiana and the other based on sundials and timelines observed during the Science Tour in Germany and Austria. A third submission modeled on the Public Forum seen at the Bradbury Museum in Los Alamos will be submitted during this semester.

Personal Benefits

This year of sabbatical leave has been incredible! I was able to indulge myself decadently in areas that I simply never had time for. The reading required for the courses and the research needed to develop the vignettes required huge blocks of time. What was amazing was that I would spend six or seven hours on one of these tasks and feel as if ten minutes had passed! I truly was able to indulge my passion while achieving my goals and creating useable products.

The change of pace from the demands of teaching was relaxing and invigorating. As I prepared to return to the classroom, I found myself excited to be able to share my enthusiasm with my students. I was thrilled to see that the new text chosen for CHEM 50 included an excerpt from one of the texts used for the HSTS 411 course I took. I presented the vignette "Chemistry", on the origins of chemistry, to my CHEM 20 class on the first day of the fall 2009 semester. The students seemed interested; I look forward to using more of these in my classes this semester.

Another unanticipated benefit occurred when I became a student. I was reminded of life on the other side of the podium. Having to log on to Blackboard as a student for the first time, download an assignment and upload my homework was a humbling event! This experience will definitely make me more empathetic regarding the day to day challenges faced by students.

Benefits to Students

The immediate benefit to my students is that they have an instructor who is rested, refreshed and passionate about the subject of chemistry. My students will be exposed to the remarkable people and events in the vignettes. I have scheduled presentation of vignettes to correlate with the syllabus. Hopefully, students will view the material in the pages of their textbooks with a little more interest when they connect it to a human face, a significant event or something in their everyday life.

Benefits to the Chemistry Department

The obvious benefit to the Chemistry Department is that the vignettes that have been created will be available on the Department server and all faculty members will have access to them. Chemistry instructors who are interested in the historical context of science but don't have time to develop ideas will have materials available. The vignettes will be correlated to topics in each course. Instructors will be able to click on a chemistry course, and then a topic to view available vignettes. The vignettes will be stored as PowerPoint presentations, ready to be shown to students.

Exhibits mounted in the display cases will provide interesting material to read between classes. Any student passing through the halls between classes will benefit from seeing the some of the topics covered in classes presented in a more informal, interesting, historical manner than what is usually seen in textbooks.

Benefits to the College

The Natural Science Exploratorium will benefit from the ideas proposed for exhibits. As construction of the facility is completed, it will be time to plan for meaningful and interesting displays. During my sabbatical, I searched for ideas for displays that were relevant to all departments in the Natural Science Division. Hopefully, some of the ideas that I have submitted can be developed into exhibits that will be beneficial to all students – whether majoring in science, or taking a course for general education.

The College will eventually benefit from a new course. At an appropriate time, I would like to develop a general education course from my sabbatical activities. There are two possible types of courses. One possibility is to develop a lecture course that would fall under category D (Social Sciences) in the General Education requirements. This course would be a "History of Science" course and would be developed in conjunction with the History Department. The second possibility is to develop a lecture/laboratory course that would fall under category B (Science and Mathematics) in the General Education requirements. This course would be a "History of Chemistry" course and listed as a Chemistry Department offering. The course would cover materials at the same level as CHEM 10 (Chemistry for Allied Health Majors) and CHEM 40 (Introduction to General Chemistry), the two Chemistry courses most commonly used to satisfy the Area B general education requirement. Basic material such as measurement, atomic structure, molecular structure and reactivity will be presented, but from a historical perspective. Either of these courses will increase the choices of courses available for general education requirements. Both courses will increase students' understanding of science.

Appendix A – Correspondence Related to Changes to Sabbatical Proposal

5/23/2008

Dear Doctor Burley,

My sabbatical project included attending the American Chemical Society (ACS) scheduled August 17-21, in Philadelphia. Attendance at this meeting was in conjunction with visiting the Chemical Heritage Foundation research facilities in Philadelphia.

I recently became aware that the Biennial Conference on Chemical Education (BCCE) is scheduled for July 27 - 31. After reviewing the possible workshops and symposia at both conferences, it appears that the BCCE conference is more relevant to my project. Apparently when these two conferences occur so close together, more educators attend the BCCE, resulting in fewer offerings for teachers at the ACS conference.

I would like permission to substitute attendance at the Biennial Conference on Chemical Education for attendance at American Chemical Society meeting. I will still visit the Chemical Heritage Foundation in Philadelphia in conjunction with visiting New York. The time for this trip may be altered, since it will not be dictated by the ACS meeting.

I am unsure of how to go about obtaining permission to make this change. Can you give me some guidance regarding the process?

Thank you very much,

Eileen DiMauro

REPLY

The process for making substitutions is communicating the requested change to the committee with a rationale, as you have already done. This sounds like a sensible change to your plan, and I will approve this and let the committee know of your substitution.
Ginny

2/18/2009

Dear Dr. Burley,

The purpose of this email is to update the Sabbatical Committee regarding the educational activities of my sabbatical leave. As predicted by the committee, I did have difficulty getting into the on-campus courses that I had hoped to take. Luckily, I found a University with a History of Science Department that offers online courses. I enrolled in History 411; a 4 unit upper division course that covers the istory of science from its beginnings to the end of the Middle Ages. I was a bit skeptical regarding the rigor of an online course. After completing several course modules and the first exam, I have found that this course exceeds my educational expectations. I am proposing that this course and its subsequent course, History 412, be accepted for two of the three courses that I committed to take.

Thank you,

Eileen DiMauro

REPLY

Thanks for the update, Eileen. I am pleased that you were able to find substitute courses to meet your sabbatical requirement. The courses are approved.
Ginny

03/27/09

Dear Dr. Burley,

I just completed one of my History of Science classes and am enrolled in the second one for the Spring quarter. These two courses cover the topic from ancient Greece to the end of the Scientific Revolution. While thinking about my third course, I discovered two things: (1) all of the other courses that are available to me cover most of the same material, (2) the material touches only very briefly on individual scientists.

In my sabbatical proposal, I indicated that I would pursue a course of self study if an appropriate course was unavailable. I am proposing that I reseach a selection of historic interesting and inspirational scientists for the third course. I have studied Agnes, Pockels, a nineteenth century German scientist who had no post secondary education and performed all of her research in her home. It took approximately 2 weeks, including the prepartion of a Power Point presentation (attached). Since an academic quarter is 10 weeks, I would like to select 5 people from a list that I have compiled. I feel that this activity will fulfill the criteria for a course of self study, and satisfy my quest to know more about the people of science.

List of Scientists

A. Scientists who have appeared on a US stamp
   1. Allison Davis
   2. Edwin Hubble
   3. Percy Lavon Julian
   4. Ernest Everett Just
   5. Crawford Long
   6. Barbara McClintock
   7. Robert Andrews Millikan propose
   8. John Wesley Powell
   9. Joseph Priestley
   10. George Washington Carver

B. American Scientists Twentieth Century
   1. Elizabeth Lee Hazen and Rachel Fuller Brown – invented Nystatin
   2. William Boyd Allison Davis
   3. Alice Hamilton – toxicologist
   4. Arnold O. Beckman – invented pH meter
   5. Stephanie Louise Kwolek – discovered Kevlar
   6. Glenn Seaborg

C. Historic American Scientists
   1. Benjamin Rush – signer of Declaration of Independence
   2. Benjamin Franklin – signer of Declaration of Independence

D. Interesting Foreign Scientists
   1. Agnes Pockles – German chemist/physicist with no formal education who published papers in the prestigious journal Nature
   2. Alfred Nobel – invented dynamite/established Nobel prize
   3. Andres Manuel del Rio – discovered vanadium
   4. Robert Bunsen – was mentor of Mendeleev/invented Bunsen burner
   5. Dimitri Mendeleev – arranged periodic table
   6. Charles Darwin
   7. Daniel Fahrenheit
   8. Galileo
   9. Copernicus
   10. Nicholas Flamel
   11. Antoine Lavoisier

E. Ancient Foreign Scientist
   1. Abu Bakr al-Hazi Rhazes – tenth century Islamic physician
   2. Abu Ali ibn Sina (Avicenna) – tenth century Islamic scientist

Thanks,
Eileen DiMauro

REPLY

Eileen,
I'm sorry for the delayed response! This proposal sounds just fine, so you can consider this email a formal approval for the proposed change to your sabbatical proposal.
I will ask Linda to put a copy in your sabbatical file.
Ginny

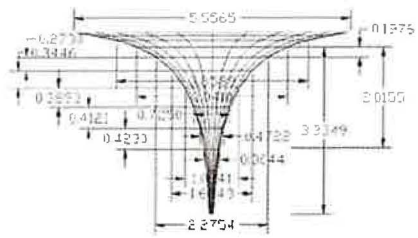
APPENDIX B Possible exhibits for the Natural Science Exploratorium

I. Submitted to Larry Redinger in August 2008

A. Gravity Well http://www.whitakercenter.org/science/PurchaseExhibits/index.asp#1

Museum Gravity Well

Take your class to a hands-on science museum. Many of these museums have gravity well exhibits that permit experiments with orbits. Small versions of gravity wells are also available at some toy and novelty stores. Use small marbles or coins to represent orbiting objects and roll them around the well. Observe the relative speeds of rolling objects that are far from the center with those close to it.



B. Garden Solar Panel with controller that allows the panel to be tilted to catch maximum sunlight
www.hoffmandesignworks.com

- **a.** Sponsored by Brabson Lab and Education Foundation and Cinergy (sp?)
- **b.** http://www.hoffmandesignworks.com/index.html
- **c.** Control Panel contained:
  Pyranometer – measures light energy
  Amp meter – measures electrical load
  Voltmeter
  DC motor
  Diodes – red, blue, green
  DC bell

Solar Power

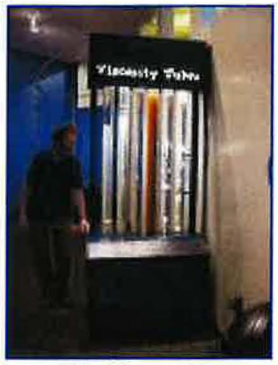
. Scanner - EMACS Scanner
1296 x 972 - 1181k - jpg
ww.hoffmandesignworks.com

C. Viscosity Tubes ***www.hoffmandesignworks.com***

Silicon oil, corn oil, glycerin, motor oil, mineral oil, water

A bubble of air is injected at bottom, either one tube at a time or all at once

Questions: shape of bubbles
Size of bubbles
Speed of bubbles



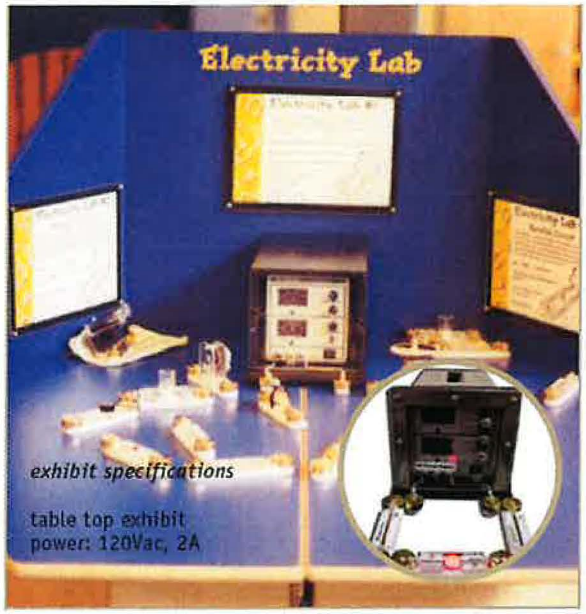
Welcome to Hoffman Design Works
972 x 1296 - 226k - jpg
www.hoffmandesignworks.com

Viscosity Tubes exhibit.

D. Electricity Lab – sponsored by Dick Blenz

Materials
- Volt power supply
- Lesson Cards – parallel circuit, series circuit …
- "Blocks" – embedded in neoprene with magnetic, circular metal connectors on each end, covered in plexiglass

Copper wire (6)	Switch	Light bulbs (2)
Resistor	Variable resistor	Capacitor
LE Diode	Buzzer	Diode



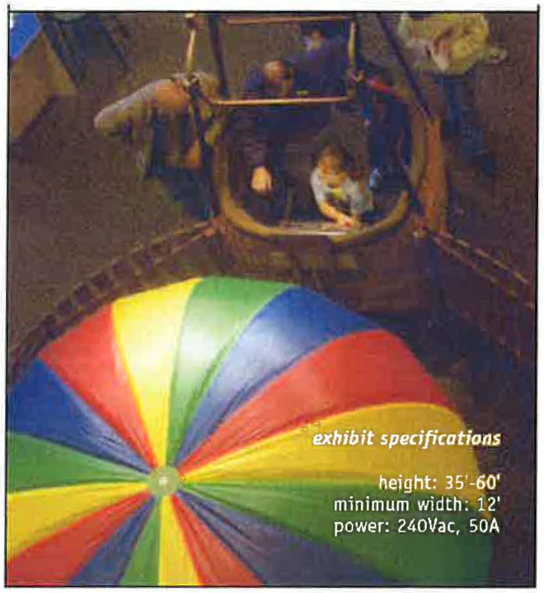
Like what you see? Call or visit us on-line at:
www.hoffmandesignworks.com

E. Magnetic Sculpture

Electromagnetics at top. A variety of metal objects to build a sculpture in a tray below, i.e., washers, flatware, screws, nuts and bolts]

Like what you see? Call or visit us on-line at:
www.hoffmandesignworks.com

F. Hot air balloon with controller



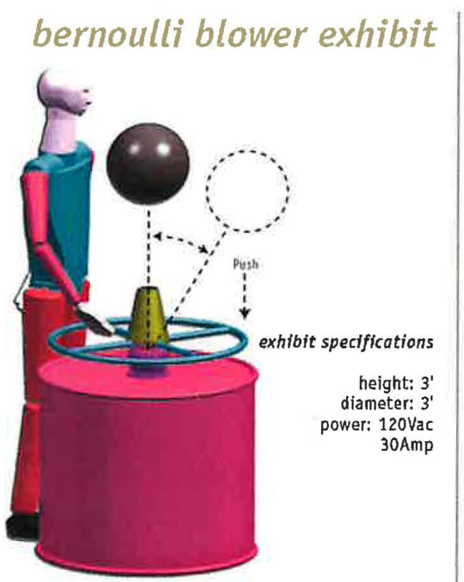
Hot-air balloon.

G. Oscylinder Scope

Can see waves on guitar strings. Large black drum with horizontal white lines. Vertical guitar strings can be strummed. When drum is spilling, you can see the waves.

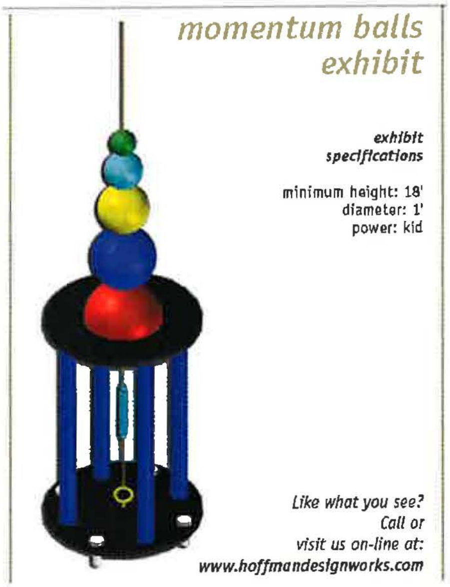
H. Bernoulli equation

PVC tubes (can be changed) connected to air blower. Ping pong balls can be placed so that they levitate in the air flow.



I. Momentum balls – descending size, fixed on metal rod

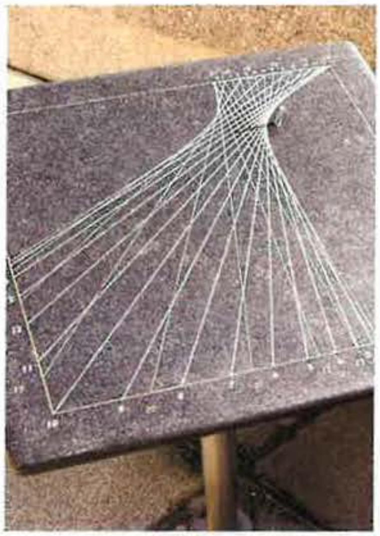
Momentum balls exhibit.



II. Examples of sundials submitted to Larry Redinger in December 2008.

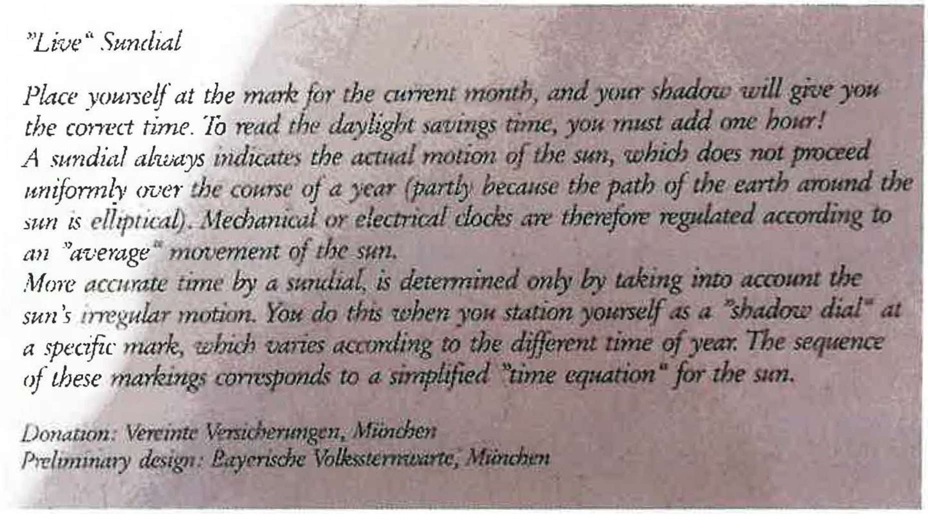
A. Burg Hochosterwitz, Austria

B. Deutsches Museum Sundial Garden, Munich Germany

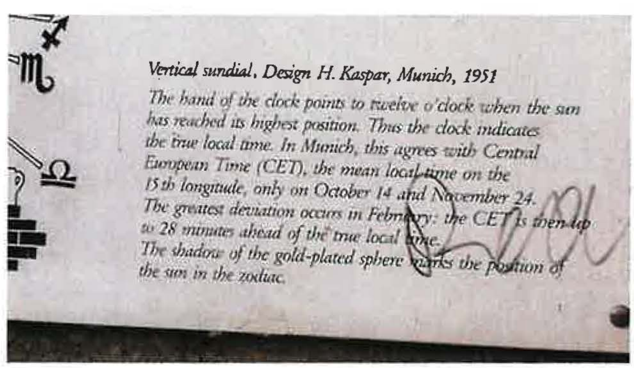


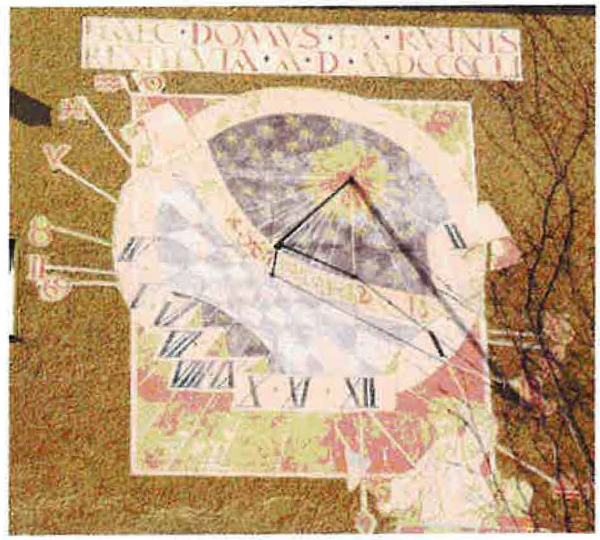

21 20 19 18 17 16
0 1 2 3 4 5 6 7 8 9 10 11 12 13

C. Deutsches Museum Courtyard, Munich Germany



D. Entrance to Deutsches Museum, Munich Germany





E. Sundial at Schloss Hellbrun, Austria

Appendix C – Bibliography and Web Links

A. Footnotes

1. 20th Biennial Conference on Chemical Education
   Program of workshops at the 20th BCCE,
   http://bcce2008.indiana.edu/workshoplist.html

2. Whitaker Center for Science and the Arts
   222 Market Street, Harrisburg, PA 17101
   http://www.whitakercenter.org/science/PurchaseExhibits/index.asp#1

3. Hoffman Design Works, Inc.
   2126 N Industrial Drive, Bloomington IN 47404
   www.hoffmandesignworks.com

4. Lee, David, **Marks in the Evolution of Western Thinking about Nature**.
   http://www.sciencetimeline.net/prehistory.htm

B. References used for general background information:

1. Freeman, **The Closing of the Western Mind**. Vintage Press, 2002.

2. Lindberg, **Beginnings of Western Science, 2nd Edition.** The University of Chicago Press, 2007.

3. Butterfield, **The Origins of Modern Science 1300-1800, Revised Edition**. The Free Press, 1965.

4. Dobbs and Jacobs, **Newton and the Culture of Newtonianism**. Humanity Books, 1995.

5. Koestler, **The Sleepwalkers: A History of Man's Changing Vision of the Universe, 2nd Edition**. Penguin Books, 1986

6. Kuhn, **The Copernican Revolution**. Harvard University Press, 1985.

C. References for Vignettes

References for each vignettes appear on the last slides.

Appendix D – Selected Pages of Compendium of Scientific Events/Breakthroughs/Discoveries

Based on "*Marks in the Evolution of Western Thinking about Nature*", by David Lee.

About 10,000 bce, wolves were probably domesticated. [added 02/01/03]

By 9000 bce, sheep were probably domesticated in the Middle East.

About 7000 bce, there was probably an hallucinagenic mushroom, or 'soma,' cult in the Tassili-n-Ajjer Plateau in the Sahara (McKenna 1992:98-137).

By 7000 bce, wheat was domesticated in Mesopotamia. The intoxicating effect of leaven on cereal dough and of warm places on sweet fruits and honey was noticed before men could write.

By 6500 bce, goats were domesticated. "These herd animals only gradually revealed their full utility--sheep developing their woolly fleece over time during the Neolithic, and goats and cows awaiting the spread of lactose tolerance among adult humans and the invention of more digestible dairy products like yogurt and cheese" (O'Connell 2002:19). [added 02/01/03] Between 6250 and 5400 bce at □atal Hüyük, Turkey, maces, weapons used exclusively against human beings, were being assembled. Also, found were baked clay sling balls, likely a shepherd's weapon of choice (O'Connell 2002:25). [added 02/01/03]

About 5500 bce, there was a "sudden proliferation of walled communities" (O'Connell 2002:27). [added 02/01/03]

About 4800 bce, there is evidence of astronomical calendar stones on the Nabta plateau, near the Sudanese border in Egypt. A parade of six megaliths mark the position where Sirius, the bright 'Morning Star,' would have risen at the spring solstice. Nearby are other aligned megaliths and a stone circle, perhaps from somewhat later.

About 4000 bce, horses were being ridden on the Eurasian steppe by the people of the Sredni Stog culture (Anthony et al. 1991:94-95). About 4000 bce, light wooden plows were used in Mesopotamia. Between 4000 and 3500 bce, copper smelting in minute quantities was introduced in Mesopotamia. [added 02/01/03]

Between 4000 and 3500 bce, copper smelting in minute quantities was introduced in Mesopotamia.

By 3500 bce, irrigation was developed in Mesopotamia.

Between 3300 bce and 2850 bce, numerals appeared in Sumerian, Proto-Elamite, and Egyptian hieroglyphics, and, somewhat later, the earliest known forms of pictographic writing.

By 3200 bce, wheeled vehicles were used in Uruk. From about 3200 bce, there exist Egyptian sailboat drawings, showing a mast with a single broad square sail hung from it. [added 02/01/03]

By 3000 bce, cotton was being grown in India.About 3000 bce, draft oxen were pulling plows and potters were using wheels in Mesopotamia.

About 2700 bce, cuneiform signs and numerals appeared on Sumerian tablets, with a slanted double wedge between number symbols to indicate the absence of a number, or zero, in a specific place. .

About 2500 bce, the Stele of Vultures shows the Sumerian infantry in a phalanx: "all wearing helmets, advancing shoulder to shoulder behind a barrier of locked rectangular shields reinforced with bronze disks, and presenting a hedgehog of spears protruding from several rows back" (O'Connell 2002:32). [added 02/01/03]

About the middle of the third millenium, bronze enabled the dagger form to be stretched into swords. [added 02/01/03]

About 2400 bce, the short, composite bow was developed by mounted archers. Unstrung it curved forward and could pierce armor at 100 yards. [added 02/01/03]

In the early **seventh century bce**, gold coins were introduced in Lydia, western Anatolia, as a standard of exchange.

About 600 bce, Thales of Miletus, arguing from the fact that wherever there is life, there is moisture, speculated that the basic stuff of nature is water, according to Aristotle.

About 560 bce, Anaximander, a monist of Miletus like Thales, said that the primal substance, the substratum of the opposites, the originative stuff, is the apeiron, which seems to have meant, at that time, the spatially indefinite or unbounded (Kirk et al. 1983:110).

About 530 bce, Pythagoras discovered the dependence of musical intervals on the arithmetical ratios of the lengths of string at the same tension, 2:1 giving an octave, 3:2 the fifth, and 4:3 the fourth. He is also credited with a general formula for finding two square numbers the sum of which is also a square, namely (if m is any odd number), $m^2+\{1/2(m^2-1)\}^2=\{1/2(m^2+1)\}^2$. "The Pythagoreans and Plato [as well as the Renaissance Neo-Platonists] noted that the conclusions they reached deductively agreed to a remarkable extent with the results of observation and inductive inference. Unable to account otherwise for this agreement, they were led to regard mathematics as the study of ultimate, eternal reality, immanent in nature and the universe, rather than as a branch of logic or a tool of science and technology" (Boyer 1949:1). Consequently, when the Pythagoreans developed the theory of geometric magnitudes, by which they were able to compare two surfaces' ratio, they were led, for lack of a system which could handle irrational numbers, to the 'incommensurability problem': Applying the side of a square to the diagonal, no common rational measure is discoverable.

About 510 bce, Almaeon of Crotona, a member of the Pythagorean medical circle, located the seat of perception in the brain, or enkephalos, and maintained that there were passages connecting the senses to the brain, a position he was said to have arrived at by dissections of the optic nerve.

About 500 bce, Heraclitus of Ephesus maintained that permanence was an illusion and the only possible real state was the process of becoming. He also said that to the logos, all things are one, all opposites are joined. Logos, a word which Anaximander also used, seems to be a principle manifesting itself in the process or cohering of things, and to occupy a place in Greek ideology similar to dharma for Hindus or 'Wisdom' for Jews (Park 1990:10).

About 500 bce, Xenophanes examined fossils and speculated on the evolution of the earth.

About 480 bce, Parmenides of Elea founded the Eleatic School where he taught that 'all is one,' not an aggregation of units as Pythagoras had said, and that to arrive at a true statement, logical argument is necessary. Truth "is identical with the thought that recognizes it" (Lloyd 1963:327). Change or movement and non-being, he held, are impossibilities since everything is 'full' and 'nothing' is a contradiction which, as such, cannot exist. "Parmenides is said to have been the first to assert that the Earth is spherical in shape...; there was, however, an alternative tradition stating that it was Pythagoras" (Heath 1913:64).

[[Corollary to Parmenides' rejection of the existence of 'nothing' is the Greek number system which, like the later Roman system, refused to use the Babylonian positional number system with its marker for 'nothing.' Making no clear distinction between nature and geometry, "mathematics, instead of being a science of possible relations, was to [the Greeks] the study of situations thought to subsist in nature" (Boyer 1949:25). Moreover, "almost everything in [Greek] philosophy became subordinated to the problem of change.... All temporal changes observed by the senses were mere permutations and combinations of 'eternal principles,' [and] the historical sequence of events (which formed part of the 'flux') lost all fundamental significance" (Toulmin and Goodfield 1965:40).]]

About 470 bce, Zeno of Elea propounded forty paradoxes probably to point out inconsistencies in Pythagorean positions. One of the most famous is this: The fleeing and slower runner can never be overtaken by the faster, pursuer because the faster must first reach the point where the slower is at a that time, but by then the slower will be some distance ahead. Other paradoxes made the same or apposite points, but, in fact, mathematical analysis shows that infinite aggregates and the nature of the continuum are not self-contradictory but only counter to intuition.

About 450 bce, Empedocles of Agrigento explained changes in quality or quantity of a thing as movement by the basic particles of which the thing consisted, Fire, Earth, Air, and Water. These elements mix and separate "under the guidance of two opposing principles, Love, which draws them together, and Strife, which drives them apart" (Park 1990:25).About 450 bce, Anaxagoras of Athens taught that the moon shines with the light of the sun and so was able to explain the eclipses.

About 440 bce, Leucippus of Miletus said that the world consisted in the void and atoms, which are imperceptible individual particles that differ only in size, shape, and position. That these particles were imperceptible meant they met Parmenides' objection to the Pythagorean's geometric points and, since they alone were unchanging, change could be explained as mere sense impressions. "It is scarcely an exaggeration to say that even in 1900 the only new idea to Leucippus's theory was that each chemical element was identified with a separate atomic species" (Park 1990:41).

About 440 bce, Protagoras of Abdera held that man is the measure of all things by which he meant that we only know what we perceive, not the thing perceived (Dictionary of Philosophy 1984:273). About 440 bce, Oenopides of Chios probably created the first three of what became Euclid's 'postulates' or assumptions. What is postulated guarantees the existence of straight lines, circles, and points of intersection. That they needed to be postulated is because they require 'movement,' the possibility of which was challenged by the Eleatics (Szabó 1978:276-279).

About 430 bce, Hippocrates of Chios squared the lune, a major step toward squaring the circle, probably using the theorem that circles are to one another as the squares of their diameters.

Prior to about 425 bce, Herodotus wrote the first scientific history; that is, he began by asking questions, rather than just telling what he thinks he knows. Moreover, these questions were "about things done by men at a determinate time in the past, [and the history itself] exists in order to tell man what man is by telling him what man has done" (Collingwood 1946:18).

About 420 bce, Democritus of Abdera developed Leucippus's atomic theory: Atoms vibrate when hitched together in solid bodies and exist in a space which is infinite in extent and in which each star is a sun and has its own world. He also produced two major concepts in the history of ideas concerning the brain--that thought was situated there and, anticipating the nervous system, that psychic atoms constituted the material basis of its communication with the rest of the body and the world outside. Socrates, and hence the Platonic school, followed Democritus in locating thought in the brain.

About 400 bce, Hippocrates of Cos, also locating thought, pleasure, and pain in the brain, maintained that diseases have natural causes, and observed that head injuries led to impairments on the opposite side of the body. The 'Hippocratic method' of treatment of the sick was to keep the patient in bed and let nature take its course.

About 400 bce, an arrow-shooting catapult was developed at Syracuse. Its main significance is that it "embodied the deliberate exploration of physical and mechanical principles to improve armaments" (O'Connell 2002:86) [added 02/01/03]

After about 380 bce, Plato said, in the Timaeus, that "as being is to becoming, so is truth to belief" (Plato 1929:29c). In other words, we can only believe, not know, on the basis of experience. Like, Parmenides, he held being and truth, indeed the world, to be timeless and unchanging, an ideal of which man can only hold the idea. This permitted him a certain amount of flexibility: He was willing to accept objections to his view of the universe, for example, if the new hypothesis would provide a rational explanation or 'save the appearance' presented by the planets. In the Timaeus, he also held that the 'world soul' was constructed according to mathematical principles, and, therefore, these principles are already fixed in the individual. (Forms or ideas that have existence independent of any particular mind came to be called archtypes.) He scattered reflections on mathematical issues throughout his dialogues; e.g., in the Meno, he illustrates the difference between a class and its members by reference to the difference between defining 'figure' and enumerating specific figures. References to ratios and proportions are everywhere. The five regular polygons he ascribed to the four elements plus the "decoration" of the universe (Plato 1929:55c), probably the animals of the zodiac.

By the fourth century bce, Babylonian astronomers had learned enough about the moon's motion that they could predict the occurence of lunar eclipses.

About 370 bce, Eudoxus of Cnidus invented a model of twenty-seven concentric spheres by which he was able to calculate the sun's annual motions through the zodiac, the moon's motion including its wobble, and the planets' retrograde motion. He used what came much later to be called the 'exhaustion method' for area determination. This method involved inscribing polygons within circles, reducing the difference ad absurdum, and was wholly geometric since there was at that time no knowledge of an arithmatical continuum, at least among the Greeks.

By about 335 bce, Aristotle had said that universals are abstractions from particulars and that we "have knowledge of a scientific fact when we can prove that it could not be otherwise." But "since observation never shows whether this is the case," he established "reason rather observation at the center of scientific effort" (Park 1990:32). A deductive argument is "a 'demonstration' when the premises from which the reasoning starts are true and primary.... Things are 'true' and 'primary' which are believed on the strength not of anything else but themselves" (Aristotle 1928:100a-100b). Aristotle defined the syllogism as a formal argument in which the conclusion necessarily follows from the premises, and said that the four most common statements of this sort are 'all Subject is Predicate,' 'no S is P,' 'some S is P,' and 'some S is not P.' He also discerned four sorts of 'cause.' The 'formal cause' is the design of a thing. The 'material cause' is that of which it is made. The 'efficient cause' is the maker. And the 'final cause' is the purpose of the thing. Aristotle also insisted on the operational character of mathematics and rejected any metaphysical character of number. At the same time, Aristotle often states both his observations and his reasons with rather too much conviction: "The shape of the heaven is of necessity spherical; for that is the shape most appropriate to its substance and also by nature primary" (Aristotle 1930:286b). "A heavenly essence could not, according to [his] physics, manifest any but its own 'natural' movement, and its only natural movement [so his reason informed him] was a uniform rotation around the center of the universe" (Duhem 1908:15). His name for the heavenly essence, the quintessence, is aiqhr, of which the Latin cognate is 'aether' (Although Aristotle is perhaps the earliest theorist of aiqhr, he was not the first to use the word, e.g., Heraclitus used it to mean heavenly fire.) In fact, "in dealing with [any] concrete, physical problem, it is...always necessary to take into account the world order, to consider the realm of being to which a given body belongs by its nature.... It is only in 'its' place that a being comes to its accomplishment and becomes truly itself" (Koyré 1968:6,24n1). He also put forth the view that each species has an essence and that divergence from this type was not possible beyond a certain limit. These remained the dominant views until the acceptance of those of Johannes Kepler, in the first case, and Charles Robert Darwin and Alfred Russell Wallace, in the second. If the properties of a thing are its 'form,' then, according to Aristotle, perception is the process whereby the form, and not just the representation of it, enters the soul. This account of perception "was taken as the exact, literal truthby almost every educated person down to the sixteenth century" (Park 1990:44). Also, Aristotle "considered the changes undergone by inanimate things to be analogous to those seen in the biological world. Thus grape juice is the infantile form of wine, fermentation is the process of maturation; the further change to vinegar is the death of the wine" (Fruton 1972:24). Since all matter is formed from the mixture of the four elements, he taught the elements are not permanent and could be transmuted one into another, inspiring all who practice alchemy. After weighing the evidence, Aristotle decided that the organ of thought and sensation was the heart. But he was also the first to perceive the antithesis between epigenesis, "fresh development," and preformation, the "simple unfolding of pre-existing structures." The subsequent history of this controversy is "almost synonomous with the history of embryology" (Needham 1934:40). [revised 02/01/03]

About 330 bce, Heraclides of Pontus said that the earth turns daily on its axis "while the heavenly things were at rest..., considered the cosmos to be infinite..., [and] with the Pythagoreans, considered each planet to be a world with an earth-like body and with an atmosphere" (Dreyer 1906:123-125). He also suggested that Mercury and Venus have the sun at the center of their spheres.

In 323 bce, Theophrastus, suceeded Aristotle as head of the Peripatetic school of philosophy of which he was the co-founder. In Historia Plantarum and De Causis Plantarum, he classified and described the "external parts of plants from root to fruit..., set forth the 'homology' of the perianth members [or floral envelope] of flowers..., to some extent distinguished between monocotyledons and dicotyledons, [and] described the fertilization of the date palm" (Crombie 1952:367).

About 310 bce, Autolycus of Pitane defined uniform motion as being when "a point is said to be moved with equal movement when it traverses equal and similar quantities in equal times" (Clagett 1959:164).

About 300 bce, Eukleides, better known as Euclid, published his Elements, a reorganized compilation of geometrical proofs including new proofs and a much earlier essay on the foundations of arithmetic. Elements conclude with the construction of Plato's five regular solids. Euclidean space has no natural edge, and is thus infinite. In his Optica, he noted that light travels in straight lines and described the law of reflection.

About 300 bce, Epicurus attempted to deal with the contradiction between atoms falling through the void in parallel paths at the same speed and the appearance of novel combinations, or matter, by supposing very slight, chance deviations, or 'clinamen,' in an atom's path. He saw this as analogous to the question of human freedom in a determined nature; i.e., there is no room for ethical considerations Indeed, "Epicureans saw the evelopment of the world as a random, one-way process" (Toulmin and Goodfield 1965:50).

About 280 bce, Herophilus of Alexandria studied anatomy and compared humans and animals, distinguished between sensory and motor nerves,and between the cerebellum and the brain, noted that the cortex was folded into convolutions, and named the 'duodenum.' [revised 02/01/03]

About 260 bce, Aristarchus of Samos, in On the Sizes and Distances of the Sun and Moon, used trigonometry to estimate the size of the Moon and its distance by the Earth's shadow during a lunar eclipse. Archimedes and others said that he maintained that the Moon revolved around the Earth and the Earth around the Sun which remained stationary like the stars.

About 260 bce, Archimedes of Syracuse contributed numerous advances to science including the principle that a body immersed in fluid is buoyed up by a force equal to the weight of the displaced fluid and the calculation of the value of p. "His method was to select definite and limited problems. He then formulated hypotheses which he either regarded, in the Euclidean manner, as self-evident axioms or could verify by simple experiments. The consequences of these he then deduced and experimentally verified" (Crombie 1952:278).

About 250 bce, Erasistratus of Alexandria dissected the brain and distinguished between the cerebrum and the cerebellum.

About 250 bce, 'zero' appeared in the Babylonian place-value system.

About 1000, Ibn Sina, or Avicenna, hypothesized two causes of mountains: "Either they are the effects of upheavals of the crust of the earth, such as might occur during a violent earthquake, or they are the effect of water, which, cutting itself a new route, has denuded the valleys, the strata being of different kinds, some soft, some hard.... It would require a long period of time for all such changes to be accomplished, during which the mountains themselves might be somewhat diminished in size" (Toulmin and Goodfield 1965:64). In Kitah al-Shifa, he denied the Aristotelian notion that an object thrown through the air is pushed by that air and held that "every motion occurs through a power in the moving object by which it is impelled" (Avicenna, quoted in Pines 1975:141). He also published Al-Quanun, or Canon of Medicine, where he held that medicines were to be known either by experiment or by reasoning. About 1000, Ibn al-Haitam, or al-Hazen, in Opticae Thesaurus, introduced the idea that light rays emanate in straight lines in all directions from every point on a luminous surface. He also discussed spherical and parabolic mirrors and was aware of spherical aberration. In Epitome of Astronomy, he took a position against Ptolemy, insisting that the hypothetical spheres corresponded "to the true movements of really existing hard or yielding bodies [and] so...were accountable to the laws of physics" (Duhem 1908:28). This led to disageements that persisted through the twelfth century.

Early in the eleventh century, crossbows with sights and mechanical triggers were introduced into warfare.

About 1050, Solomon ben Judah Ibn Gabirol, or Avicebron, held that every material thing possesed a 'common corporeity' which was continuous through the universe.

[In 1054, Chinese astronomers at the Sung national observatory at K'ai-feng observed the explosion of a supernova in the Crab Nebulae, visible in daylight for twenty-three days. Since then debris has moved out about three light years.]

In 1079, Omar Khayyam, computed the length of the year as 365.24219858156 days, which approaches the accuracy of the late 16th century Gregorian Calendar. The length of a year decreases in the sixth decimal within a typical human lifetime and is today 365.242190 days. Khayyam also, in Treatise on Demonstrations of Problems in Algebra, produced a complete classification of cubic equations and their geometric solutions.

As early as 1091 or 1092, Walcher of Malvern, having observed an eclipse in Italy, determined the difference in longitude of England by discovering the time which it was observed there.

By the twelfth century, alchemists had developed the art of distillation to the stage at which distillates could be captured by cooling in a flask, and wine could be distilled to yield aqua vitae.

About 1512, Nikolaus Kopérnik, better known as Copernicus, circulated a manuscript, the Commentariolus, which hypothesized that the Earth was a planet and planets revolved in circles and epicircles around the Sun, that the Earth rotated daily, and regressions in planetary orbits were explained by the Earth's motions (Park 1990:143). The problem, as he saw it, was to save the appearance of the phenomena with an hypothsis which was compatible with the principle of physics that hypotheses be founded in the truth of nature, and to demonstrate that to reject this hypothesis meant that the appearances were not saved. [It is the notion that the universe is earth- and, hence, man-centered and, therefore capable of being personalized and animated which distinguishes primitive man from civilized man.]

In the early sixteenth century, Theophrastus Bombastus von Hohenheim, who called himself Philippus Aureolus Paracelsus, opposed the four humors of Galenic medicine with "a triad of chemical properties: combustibility (termed 'sulphur'), fluidity and changeability (termed 'mercury'), solidity and permanence (termed 'salt').... The medical doctrine of Paracelsus was a new humoralism, but it emphasized the use of specific medicines for specific diseases" (Fruton 1972:29). He wrote prolifically in German and his On Diseases of Miners is the earliest book on occupational diseases.

In 1521, Berengario da Carpi, in a commentary on Mondino, observed that "the kidney is not a sieve [and] the bladder [has] no opening other than the urinary pores..., gave the first clear accounts of the vermiform appendix, the thymus gland and other structures..., and coined the term vas deferens" (Crombie 1952:371).

In 1527, Matteo Bresan, supervisor of the Venice Arsenal, oversaw the construction of a full-rigged sailing ship with lidded gunports, called a 'galleon.' [revised 02/01/03]

In 1530, Girolamo Fracastoro published a long poem, Syphilidis, sive, De mordo gallico libri tres, the disease taking its name from the poem. He also identified typhus.

In 1535, Niccoló Fontana, who was called Tartaglia, demonstrated a solution for cubic equations, but did not reveal the details. When finally published in 1545, the expression was seen to be "built up from the coefficients by repeated addition, subtraction, multiplication, division, and extraction of roots. Such expressions became known as radical expressions" (Stewart 1989:xiv). This formula was "probably the first great achievement in algebra since the Babylonians" (Davis and Hersh 1981:196).

In 1537, Ambrose Paré revived the practice of ligature for gunshot wounds, replacing cautery with hot oil. Later, he performed herniotomies and manipulated fetuses so they could be born feet first.

In 1541, Giambattista Canano published illustrations of each muscle and its relation with the bones.

In 1543, Andreas Vesalius published a large collection of meticulous anatomical drawings, emphasizing especially the systems of organs.

In 1543, Copernicus published De revolutionibus orbium coelestium. Although he made some astronomical observations, this work is that of a mathematician using Ptolemy's data, who could read Greek and cite Aristarchus of Samos.NeoPlatonic and NeoPythagorean influences loom large: "In the center of it all rests the Sun. For who would place this lamp of a very beautiful temple in another or better place than wherefrom it can illuminate everything at the same time? As a matter of fact, not unhappily do some call it the lantern; others, the mind and still others, the pilot of the world. Trismegistus calls it a 'visible god'" (Copernicus 1543:527). In so placing the Sun, Copernicus "overthrew the hierarchy of positions in the ancient and medieval Cosmos, in which the central was not the most honorable, but, on the contrary, the most unworthy. It was, in effect, the lowest, and consequently appropriate to the Earth's imperfection. Perfection was located above in the celestial vault, above which were 'the heavens,' whilst Hell was deservedly placed beneath the surface of the Earth" (Koyré 1961:114n24).

In 1543, Pierre de la Ramée published two books of logic which were anti-Scholastic and anti-Aristotelian and were very influential in Protestant countries in the following century.

About 1586, Galileo wrote a manuscript, De motu gravium, which showed that the ratio between the gravity of a moving body on an inclined plane and gravity acting on free fall is the sine of the angle which the plane forms with the horizontal.

In 1590, Zacharias and Hans Janssen combined double convex lenses in a tube, producing the first telescope.

In 1591 and 1592, Thomas Harriot, or sometimes Hariot, measured an angular distance of 2 degrees 56 minutes between the celestial North Pole and the North Star. [added 02/01/03]

In 1591, François Viète, in In artem analyticam isagoge, demonstrated the value of symbols to represent unknowns and suggested the use of letters. He also introduced the term 'coefficient.'

About 1592, Galileo found that the path of a projectile is a parabola by assuming that the uniform motion preserved in the absence of an external force is rectilinear. The acceptance of a straight rather than a circular path as natural became a crucial turning point in planetary mechanics.

About 1610 or 1611, William Shakespeare created the earliest remembered opposition of 'nature' and 'nurture' when he had Prospero describe Caliban, in the Tempest, as "a born devil, on whose nature, nurture can never stick" (Shakespeare 944:51).

In 1611, Kepler, in Dioptrice, explained the principles involved in the convergent/divergent lenses of microscopes and telescopes and suggested that telescopes could be built using only convergent lenses. Astronomical lenses became this type.

In 1612, Galileo, in Discorso intorno alle cose cho stanno in su l'acqua, observes that the roles of a lever, a windlass, a capstan, a pulley, and a block and tackle each consist "in transporting a great resistance very slowly and without dividing it by means of a small force moving rapidly" (Duhem 1905:179).

In 1614, Kepler, in the Epitome Astronomiae Copernicanae, said that an astronomer "ought to be able to provide reasons for the hypotheses [they] claim as the true causes of appearances, [and they] ought, therefore, at the outset, to seek the foundationsof [their] astronomy in a higher science, I mean, in physics or metaphysics" (Kepler, quoted in Duhem 1908:103). For example, in his quest for a numerically ordered solar system, Kepler postulated an unobserved planet in the gap between Mars and Jupiter.

In 1614, John Napier, in Mirifici logarithmorum canonis descriptio, created the first logarithmic tables and the first use of the word 'logarithm.' It was not published until 1619. Napier also introduced the decimal point in writing numbers.

In 1614, Isaac Casaubon demonstrated that the Hermetic writings in the Pimander were not the magical practices of a very ancient Egyptian priest but dated from post-Christian times. This "is a watershed separating the Renaissance from the modern world. It shattered at one blow the build-up of Renaissance NeoPlatonism" (Yates 1964:398).

In 1615, Kepler, in Steriometria doliorum, showed, following Cusa's exhaustion method, that the volume of a sphere is one-third the product of its radius times the surface area of an infinite number of cones, and that of all right circular cylinders inscribed in a sphere, that one is the greatest which has the diameter and altitude in the ratio of the square root of 2 to 1. Kepler was concerned with statics and 'indivisibles' and expressed himself in numerical increments.

In 1619, Kepler, in Harmonica mundi, published his third law: The square of the length of a planet's year varies with the cube of the mean radius of its orbit. His three laws "are the only three exact and general mathematical laws of planetary motion, applying not only to this but to all similar planetary systems. And he contributed a further revolutionary idea: that the planets move in their orbits...because the Sun exerts a force that causes them to move as they do" (Park 1990:157). However, none of Kepler's laws was deduced from a consistent theoretical framedwork, which work was left for Newton.
In 1631, Gassendi obderved the transit of Venus across the Sun, establishing that its orbit lies closer to the Sun than does the Earth's orbit.

In 1632, Galileo published a work in Italian for the non-specialist, the Dialogo, comparing the Ptolemaic system unfavorably to the Copernican. For this, he was tried by the Inquisition in 1633 and forced to abjure belief that the Sun was central and that the Earth moved. In addition, Due massimi sistemi contains Galileo's construction of the concept of 'inertia,' perpetual motion being the limiting case: In an ideal world without friction, given the acceleration and retardation of a body by gradually sloping planes tending toward horizontal, momentum persists indefinitely. "Force could therefore be defined as that which produced, not velocity, but a change of velocity from a state of rest or of uniform velocity" (Crombie 1952:301). When a body is acted on by two forces, each is independent of the other. "Galileo's conception of science as a mathematical description of relations enabled him to...free [methodology] from the tendency to excessive empiricism" (Crombie 1953:305). Thus 'gravity' was only the name for an observed regularity, with antecedent cause to be discovered by experiment, and not an 'essential cause;' i.e., "mathematical substance was substituted for Aristotelian qualitative substance as the identity persisting through change" (ibid.:310).

Probably in 1633, Descartes wrote Le Monde wherein "subtle matter, his celestial matter, what his contemporaries called 'the Cartesian aether,' comprises the second element [i.e., 'air'] permeated, as always by the first [i.e., 'fire']" (Cantor and Hodge 1981:12). The third and final element is 'earth.' It was published posthumously in 1664.

In 1635, Bonaventura Francesco Cavalieri published a purely geometric theory of indivisibles.

In 1636, Galileo finished his final book, Discorsi e dimostrazioni matematiche interno a due nuove scienze, which contained most of his physics and some strenghtened arguments. The two sciences are statics and dynamics. The Discorsi, together with the Dialogo, both works of popular science, "helped create a new age of scientific thought with their emphasis on observation, common sense, clear language, and persuasion by reasonable arguments" (Park 1990:206).

In 1637, Descartes, in Discours de la Méthod pour bien conduire sa raison, et chercher la vérité dans les sciences, held that science begins with observation which is followed by analysis, leading to the intuition of the self-evident nature of a proposition, and synthesis, or the reconstitution of the original observation. Included with this work were three exemplary treatises: La Dioptrique, where 'matière subtile' includes whatever particles transmit light, La Gèometrie, where he demonstrated the so-called Cartesian coordinates and Cartesian curves, and, in algebra, where he contributed the convention of exponent notation, a study of negative roots, and the convention whereby known quantities are represented by letters near the beginning of the alphabet and unknowns by letters at the end; and Météores, where he showed that the primary rainbow was produced by sun rays coming to the eye at an angle of about 41 degrees.

By 1683, Anton van Leeuwenhoek, with microscopes, some of which magnified 270 times, had seen red blood cells, sperm cells, and almost all classes of microorganism known today. He hypothesized that these were carried in the air, not spontaneously generated. Also, van Leeuwenhoek was able to faithfully describe the nervous system and was the first to describe the life cycle of an ant, from egg to larva to pupa to adult. [added 02/01/03]

In 1684, Gottfried Wilhelm von Leibniz published his system of calculus, developed independently of Newton. It is Leibniz's notation which has been adopted. He also invented a scheme for a logical syntax which he called the 'Universal Characteristic' and which "was supposed to enable us to compute the probabilities of disputed hypotheses relative to the available data" (Hacking 1975:140).

In 1687, Newton published Philosophiae naturalis principia mathematica, a summary of his discoveries in terrestial and celestial mechanics in which he makes continual use of Euclidean theorems and constructions, and the first published account of his calculus. In contrast to Kepler, he did not explain the features of the solar system by deducing them from a purpose. In contrast to Descartes, he carefully preserved the distinction between mathematical descriptions and theories about matter and causation. For example, writing of gravitational attraction, he said that "our purpose is only to trace out the quantity and properties of this force from this phenomena, and to apply what we may discover in some simple cases [e.g., the moon] as principles by which, in a mathematical way, we may estimate the effects thereof in more involved cases [e.g., the planets]".... Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration (Newton 1729:550). The first part of the Principia concerns dynamics and includes his laws of motion, the second concerns fluid motion, and the third, the mechanical unity of his principle of gravitational attraction in relation to the 'centripetal force' of the planet's motion, that is, Kepler's laws of planatary motion. "Newtonian mechanics [may be] understood as the combination of two laws: the law of motion, according to which force is equal to mass times acceleration; and the law of universal gravitation, according to which the force of attraction between two bodies is proportional to the product of their masses and inversely proportional to the square of the distance separating them" (Sokal and Bricmont 1998:64). "In opposition to the pre-Galilean and pre-Cartesian conception, which understood motion as a species of becoming..., the new, or classical, interpretation interprets motion as a kind of being, that is, not as a process, but as a status, a status that is just as permanent...as rest" (Koyré 1965:9). Holding that the Earth's rotation, its motion, is relative to absolute space, Newton finds it necessary to distinguish "time, space, place, and motion...into absolute and relative, true and apparent, mathematical and common. [E.g.,] absolute space, in its own nature, without relation to anything external, remains always similar and immovable".... Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration (Newton 1729:6). At the same time, Newton wished to demonstrate that the world which obeyed these laws was compatible with the sort of atoms which he imagined, atoms which were aethereal forces as everything else. These forces counted among their number, at a minimum, inertia and gravity, which are proportional to each other, cohesion, or the mutual attraction and repulsion that the particles have for each other, and fermentation, and were, so Newton believed, "capable of holding identical particles in a sufficient variety of patterns to explain all the manifold diversity of Nature" (Thackray 1970:15). Between the gravitating bodies are particles of a rarified medium, or aether, which are the repelling force. Similar particles also account for the force which deflects the light through a prism (Cantor and Hodge 1981:1-2). In addition, these forces were also capable of alchemical transmutation, i.e., "every body can be transformed into a body of another kind, and can take on all the intermediate grades of qualities" (Newton, quoted in Koyre 1965:14). This, from the first edition, was modified in the 1713 edition and that modified in the 1729 edition, reflecting shifts in Newton's thought. In other words, there are two trends: The panmathematism of Galileo and Descartes and the empirical, experimental 'corpuscular philosophy' of Gassendi, Roberval, Boyle, and Hooke. "From this perspective...Newton presents us with a synthesis of both trends, of both views" (Ibid.:12). As for Newton's particles vis □ vis Huygens' waves, it was not understood until the nineteenth century that these conceptions were not contradictory but complementary.

Appendix E – Printout of Mendeleev Vignette (Example of Biographical Vignette)

Dmitri Mendeleev
The Man Behind the Periodic Table

Portrait of Dmitry Ivanovich Mendeleev wearing the Edinburgh University professor robe. Watercolor.
Ilja Jefimowitsch Repin 1885
The State Tretyakov Gallery, Moscow

1

Early Life

- Born February 1834 in Verhnie Aremzyani village, near Tobolsk, Russia (Siberia).
- Youngest of at least 14 siblings, but the exact number differs among sources.
- Father: Ivan Pavlovich Mendeleev (died in 1848).
  - Teacher of literature and philosophy.
- Maria Dmitrievna Mendeleeva (died in 1850).
  - Brilliant and self-educated.
  - Managed a local glass factory founded by her family.

The Tobolsk Kremlin panoramic view

2

Early Life

- Educated in the local schools in Tobolsk.
- Showed an aptitude for math and science.
  - Not considered an outstanding student in his early education partly due to his dislike of the classical languages.
- After disasters struck his family in 1848, he and his mother relocated to Moscow and then St. Petersburg to pursue education opportunities.
  - His father died that year.
  - His family's glass factory was destroyed by fire.
- Denied admission to both the University of Moscow and St. Petersburg University because of his provincial background and unexceptional academic background.

3

Education

- Finally was admitted to the Main Pedagogical Institute (St. Petersburg Institute) in 1850.
  - His mother died shortly after he was admitted.
  - Published first article in 1854, at the age of 20.
  - Received Student of the Year Award by the institute in 1855.
- After graduation, received a teaching position at a high school on the Crimean Peninsula.
  - He taught math and physics in high school.
  - It lasted a year with the Crimean War in full swing.
- Admitted to graduate work at St. Petersburg University.
  - Earned a Master's degree in physics and chemistry in1856.
  - Was so impressive, his instructors at St. Petersburg University offered him as position as a *privat-docent* lecture in chemistry.

4

Further Training in Europe 1859 to 1861

- Studied gas density with the chemist Henri Victor Regnault in Paris.
- Studied spectroscopy with the Robert Bunsen and Gustav Kirchhoff in Heidelberg.
- Published several papers and began to gain recognition in Europe.

Henri Victor Regnault
Artist Unknown

Robert Bunsen and Gustav Kirchhoff
Photographer Unknown

Chemical Conference in Karlsruhe

- Mendeleev attended the first Congress of Chemists in Karlsruhe, Germany in 1860.
  - Attended by many of the leading European chemists.
  - One of the central issues was the variety of methods used to calculate atomic mass, which lead to confusion with chemical formulas and nomenclature.
  - Heard a presentation on Amedeo Avogadro's hypothesis regarding equal volumes of gases under identical conditions contained an equal number of particles.
- He returned to St. Petersburg in 1861 to continue his career in teaching and research.

6

1

Professor of Chemistry

St. Petersburg State University

- Became a professor of general chemistry at St. Petersburg University in 1866.
- Was unhappy with the choice of chemistry text-books available, so he decided to write his own: *"Principles of Chemistry"*.
  - The book appeared in 13 editions, the last being in 1947.
  - The chapter on the elements triggered his focus on connections between elements

7

First Periodic Table

Photographer unknown.

- Mendeleev noticed patterns in the properties and atomic weights of halogens, alkali metals and alkaline metals.
  - He observed similarities between the series Cl-K-Ca , Br-Rb-Sr and I-Cs-Ba.
- In an effort to extend this pattern to other elements, he created a card for each of the 63 known elements.
  - Each card contained the element's symbol, atomic weight and its characteristic chemical and physical properties.

8

First Periodic Table

- When Mendeleev arranged the cards on a table in order of ascending atomic weight grouping elements of similar properties, the periodic table was formed.
- He used the term "periodicity" to refer to the repeating patterns.

Draft for first version of Mendeleev's periodic table 17 February 1869
Courtesy Oesper Collection, University of Cincinnati

Table Presented to the Russian Chemical Society in March 1869

ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

[illegible]

			Ti=50	Zr=90	?=180.
			V=51	Nb=94	Ta=182.
			Cr=52	Mo=96	W=186.
			Mn=55	Rh=104,4	Pt=197,4
			Fe=56	Ru=104,4	Ir=198.
			Ni=Co=59	Pd=106,6	Os=199.
H=1			Cu=63,4	Ag=108	Hg=200.
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,4	?=68	Ur=116	Au=197?
	C=12	Si=28	?=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210?
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204.
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

Д. Менделѣевъ

10

Eight Observations for 1869 Presentation:

1. The elements, if arranged according to their atomic weights, exhibit an apparent periodicity of properties.
2. Elements which are similar as regards their chemical properties have atomic weights which are either of nearly the same value (eg. Pt, Ir, Os) or which increase regularly (eg. K, Ru, Cs).
3. The arrangement of the elements, or of groups of elements in the order of their atomic weights, corresponds to their so-called valencies, as well as, to some extent, to their distinctive chemical properties; as is apparent among other series in that of Li, Be, Ba, C, N, O, and Sn.
4. The elements which are the most widely diffused have small atomic weights.

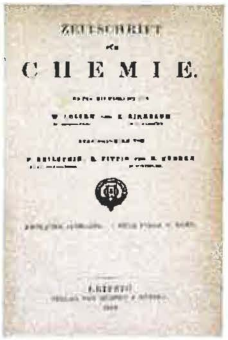
11

Eight Observations for 1869 Presentation:

5. The magnitude of the atomic weight determines the character of the element, just as the magnitude of the molecule determines the character of a compound body.
6. We must expect the discovery of many as yet unknown elements-for example, elements analogous to aluminum and silicon- whose atomic weight would be between 65 and 75.
7. The atomic weight of an element may sometimes be amended by a knowledge of those of its contiguous elements. Thus the atomic weight of tellurium must lie between 123 and 126, and cannot be 128.
8. Certain characteristic properties of elements can be foretold from their atomic weights.

12

Mendeleev's discovery of periodic law was first announced to European scientists in a short article in the German journal *Zeitschrift fur Chemie (Journal of Chemistry)* in 1869.



13

Lothar Meyer

- German chemist Lothar Meyer published a table in 1864.
  - Contained 28 elements.
  - Classified into 6 families by valence.
- Mendeleev's table did not assume that all elements were known.
  - Theorized that elements would be discovered that would fit those spaces.
  - Predicted the properties those elements.
  - This added insight gave Mendeleev the edge.
- Meyer published an updated table in 1869 which agreed with Mendeleev's table.

Julius Lothar Meyer. Courtesy Edgar Fahs Smith Memorial Collection, Department of Special Collections, University of Pennsylvania Library.

14

Later Version of Periodic Table

Row	Group I. – R²O	Group II. – RO	Group III. – R²O³	Group IV. RH⁴ RO²	Group V. RH³ R²O⁵	Group VI. RH² RO³	Group VII. RH R²O⁷	Group VIII. – RO⁴
1				H=1				
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	–=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	–=68	–=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	–=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	–	–	–	– – – –
9	(–)	–	–	–	–	–	–	
10	–	–	?Er=178	?La=180	Ta=182	W=184	–	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	–		
12	–	–	–	Th=231	–	U=240	–	– – – –

Boxes with red text indicate spaces left for unknown elements.
The red numbers indicate Mendeleev's predicted molar masses of the unknown elements

15

The Three Predicted Elements

Predicted Properties	Properties as Discovered
Eka-Aluminum (as predicted 1871) Atomic Weight: 68 Low melting point Density: 5.9 g/mL Formula of Oxide: Ea_2O_3 Chloride: Ea_2Cl_6	Gallium (discovered 1875) Atomic Weight: 69.3 Melting point: 30.15°C Density: 5.93 g/mL Oxide: Ga_2O_3 Chloride: Ga_2Cl_6
Eka-Boron (as predicted 1871) Atomic Weight: 44 Oxide: Eb_2O_3 with density 3.5 g/mL	Scandium (discovered 1879) Atomic Weight: 44.7 Oxide: Sc_2O_3, density 3.8 g/mL
Eka-Silicon (as predicted 1871) Atomic Weight: 70 Grey, difficult to melt Oxide: EbO_2 Chloride: $EbCl_4$, boiling ~100°C Fluorides: EbF_4 & M_2EbF_6	Germanium (discovered 1886) Atomic Weight: 72.04 Grey-white, melts ~900°C Oxide: GeO_2 Chloride: $GeCl_4$, boils 86°C Fluorides: $GeF_4 \cdot 3H_2O$ & M_2GeF_6

16

Mendeleev's Predictions

- Mendeleev's predictions for the three elements were remarkably close to the actual values.
- The Periodic Table of the Elements provided a unifying system for classifying and understanding the elements and their function in the composition of matter.

Photographer unknown

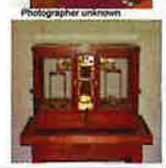
- Mendeleev received the Davy Medal (with Meyer in 1882) and the Copley Medal (in 1905), but Russia's Imperial Academy of Sciences refused to acknowledge his work.

17

Later Career

- Remained a dedicated and well-loved teacher at St. Petersberg University until 1890.
  - Did not support the Russian government's to limit education opportunities for women and "children of coachmen, footmen, laundresses and small shopkeepers".
  - Continued to admit women to his lectures.
  - Resigned from the University after receiving an official rebuke for delivering a student petition of protest to the ministry of education.

Photographer unknown



2

Later Career

- Helped to found the first oil refinery in Russia.
- Helped open the lines of communication between scientists in Europe and the United States
- One of the founding members of the Russian Chemical Society.
- In 1893, he was appointed Director of the Bureau of Weights and Measures.
  - Formulated new state standards for the production of vodka.
  - As a result of his work, in 1894 new standards for vodka were introduced into Russian law and all vodka had to be produced at 40% alcohol by volume
  - Mendeleev is given credit for the introduction of the metric system to Russian.

19

Later Career

THE STUDY
The study is one of the rooms of the apartment where he lived for many years at St. Petersburg University. It is preserved in the same state as it was during Mendeleev's lifetime.

Photographer unknown

- Died on Jan. 20, 1907 at the age of 73.
- Students carried a larger periodic table banner at his funeral.

20

Mendeleev – References

- Dmitri Mendeleev, http://en.wikipedia.org/wiki/Dmitri_Mendeleev
- Corrosion Doctors, http://corrosion-doctors.org/Biographies/MendeleevBio.htm
- http://www.youtube.com/watch?v=SmwlzwGMMwc
- Mendeleev's periodic table, http://www.webelements.com/nexus/Mendeleev_Periodic_Table
- Mendeleev's Periodic Table, Original Russian Version, Anne Marie Helmenstine, Ph.D., http://chemistry.about.com/od/imagesclipartstructures/ig/Science-Pictures/Mendeleev-s-Periodic-Table.-oEA.htm

21

Mendeleev – References

- The development of the Periodic Table, http://www.rsc.org/education/teachers/learnnet/periodictable/pre16/develop/mendeleev.htm
- Galaxy of images, http://www.sil.si.edu/imagegalaxy/imageGalaxy_enlarge.cfm?id_image=2860
- Chemical Achievers http://www.chemheritage.org/classroom/chemach/periodic/bunsen-kirchhoff.html
- http://www.chemheritage.org/classroom/chemach/pop/04periodic/meyeri.html
- St. Petersburg State University, http://www.saint-petersburg.com/virtual-tour/state-university.asp

22

Mendeleev – References

- Mendeleev's House, http://englishrussia.com/?p=629
- Chemical element. Wikipedia, http://en.wikipedia.org/wiki/File:Mendeleev%27s_1869_periodic_table.png http://homepage.mac.com/dtrapp/periodic.f/periodicity.html
- Chemists, http://e-ducation.net/chemists.htm
- Mendeleev, http://members.mrtc.com/anvk/russia04/mendeleev/mendeleev.html
- Mendeleev s Katetometr and Komparator, http://commons.wikimedia.org/wiki/File:Mendeleev_s_Katetometr_and_Komparator.jpg

23

Appendix F – Printout of "Chemistry" (Example of Topical Vignette)

Chemistry

kem – *uh* - stree

An Overview of the Origins of the Science

Origins of the Word *"Chemistry"*

- **"*Chemistry*" is derived from the European word "alchemy".**
  - **al·che·my (al – *kuh* - mee)**
- **"*Alchemy*" is generally believed to be derived from the Arabic *al - kimia:***
  - **the art of transformation.**

article "*al*" + the word "*kīmiyā*"
the transmutation

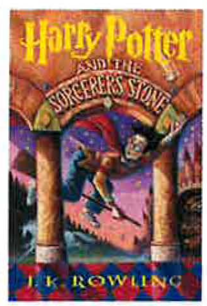
2

Origins of the Word *"Alchemy"*

- **Some scholars believe the Arabs borrowed the word *"kimia"* from the Greek word for transmutation.**
- **Others argue that its origins derived are Chinese.**
  - **From the Hakka term KIM-MI.**
  - **From the Cantonese term KEM-Mai.**
- **Words similar to "*alchemy*" are found in the ancient Persian, Greek, Chinese and Indian writings.**

3

The Principles of Alchemy



- Develop a substance called the Sorcerer's Stone that will:
  - Transform metals into gold. Gold represents the perfection of all matter on any level.
  - Cure all diseases.
  - Release a potion that gives eternal youth. This potion was named "the elixir of life".

4

Ancient Chemical Arts in Egypt

- Many historians agree that the philosophies and arts of alchemy have an Egyptian origin.
- Early alchemists in Egypt had invented mortar by 4000 B.C., allowing the building of magnificent structures.

Ancient Egypt

- As early as 3400 B.C., the Egyptians knew the process of extracting metal from ore.

Metal-Workers' Workshop in Old Egypt

Artist unknown

- Papyrus had been invented by 3000 B.C.
- Few original Egyptian documents on alchemy have survived.

6

Alchemy in Ancient China

- Taoist monks independently developed alchemy in China. The monks pursued both the outer elixir and the inner elixir.
  - The outer elixir was composed of minerals, plants etc. which could prolong life.
  - The inner elixir was the use of exercise techniques, such as Qigong, to manipulate the chi or life force of the body.

7

Ancient China

Artist unknown

- Alchemy blossomed during the Jin dynasty (265-420).
- The search for an elixir of life to confer longevity or immortality centered on the use of mercury.
- Chinese alchemists attempted to invent a pill that would recreate the changes from yin to yang and thus cause eternal life.

8

Ancient China

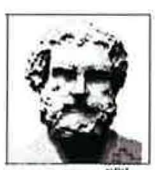
- Prominent 4th century alchemist Ko Hung (also called Ge Hong) believed that man is what he eats, and so by eating gold he could attain perfection.
  - Used research and experimentation to search for the secret of immortality.
  - Used advanced instruments, special dishes, ovens and double boilers in their experiments.
  - His book *Baopuzi* contains two chapters with recipes for elixirs, mostly based on mercury and arsenic compounds

9

Ancient Greece

- In the 4th century BC, the Greek-speaking Macedonians, under the leadership of Alexander the Great, conquered Egypt and founded the city of Alexandria.
  - It became the center of alchemical knowledge for most of the Greek and Roman periods.

Ancient Greece



Democritus artist unknown

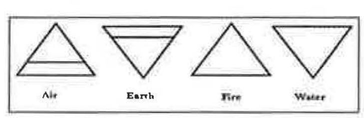
- The Greeks combined the science of the Egyptians with their strong tradition of philosophy to lay the foundation for a rational study of nature.
  - The emphasis was on reasoning.
  - Experimentation was not important.
- Democritus (430 BC) proclaimed matter was composed of atoms and that the atom was the simplest unit of matter.

11

Ancient Greece

Aristotle artist unknown

- Aristotle (300 BC) declared the existence of only four elements: *fire, air, water and earth.*
  - All matter is made up of these four elements.
  - Matter had four properties: hot, cold, dry and wet.
  - One should be able to make gold from other materials by adjusting the ratios of the four elements.



12

Roman Empire

- The rise of the Roman empire and the proliferation of Christianity helped spread scientific and mathematical knowledge.
- Augustine (AD 354-430), an early Christian philosopher, wrote of his beliefs:
  - Reasoning should be used to understand God.
  - Experimentation was evil.

13

The Arab World

- With the fall of the Roman Empire and the coming of the Dark Ages, the practice of alchemy shifted to Islamic scholars who had contact with the Greek world.
- The Islamic world was a melting pot for alchemy during the late 7th and early 8th centuries.
- Much more is known about Islamic alchemy because it was better documented.

14

The Arab World

- In the late 8th century, Jabir ibn Hayyan (aka "Geber" in Europe) introduced a scientific process to alchemy, based on controlled experimentation in the laboratory.
- He is considered by many to be the father of chemistry.

15

The Arab World

- Abu Bakr al-Hazi Rhazes (867 - 925) (also known as Razi) the Persian physician and alchemist in his laboratory in Baghdad.

From Louis Figuer's 'Vies des Savants Moyen Age', Paris - pub 1867 (Photo by Hulton Archive/Getty Images

- Refuted Aristotle's theory of four classical elements for the first time.
- Set up firm foundations of modern chemistry using the laboratory in the modern sense, designing and describing more than twenty instruments.

16

Medieval Europe

- The introduction of alchemy to the West came in the 8th Century when the Arabs imported the principles to Spain.
- Pope Silvester II, (died 1003) was one of the first to bring Islamic science from Spain to Europe, where it spread quickly.
- Because of its strong connections to Greek and Roman cultures, European alchemists eagerly absorbed Islamic alchemical knowledge.

17

Medieval Europe

- The first true alchemist in Medieval Europe was Roger Bacon (1214–1294), a Franciscan monk.
  - He was convinced that experimentation was more important than reasoning.

- He has been attributed with originating the search for the Sorcerer's stone and the elixir of life.

18

Medieval Europe

- Through the late Middle Ages (1300-1500) alchemists concentrated on looking for the Sorcerers' Stone and the elixir of life.
- Many alchemists during this period interpreted the purification of the soul to mean the transmutation of lead into gold.
  - These men were viewed as magicians and sorcerers, and were often persecuted for their practices

Alchemy Symbol: Sulfur and Mercury unite to form the Philosopher's Stone.

19

Medieval Europe

- Alchemy was kept alive by men such as Nicolas Flamel 1330 to 1417), one of the few alchemists writing in those troubled times.
  - He was not a religious scholar as were many of his predecessors.
  - His entire interest in the subject revolved around the pursuit of the Sorcerer's Stone, which he is reputed to have found.

20

The Renaissance

Picture by Quentin Massys

- The most important name in this period is Philippus Aureolus Paracelsus (1493–1541)
  - Rejected some of the occultism associated with alchemy.
  - Promoted the use of observations and experiments to learn about the human body.
  - Pioneered the use of chemicals and minerals in medicine.

21

The Decline of Alchemy and Rise of Chemistry

- The rise of modern chemistry in Europe began with the emphasis on rigorous quantitative experimentation.
- Robert Boyle (1627–1691).
  - Better known for his studies of gases (Boyle's law) pioneered the scientific method in chemical investigations.
  - Landmark publication is *The Sceptical Chymist*, where he attempts to develop an atomic theory of matter.

Portrait by Johann Kerseboom, circa 1689.

22

Modern Chemistry

- The person celebrated as the father of modern chemistry in Europe is Antoine Lavoisier.
  - Born Aug, 26 1743.
  - Recognized and named oxygen (1778) and hydrogen (1783).
  - Introduced the metric system.
  - Wrote the first extensive list of elements.
  - Helped to reform chemical nomenclature.

Line engraving by Louis Jean Desire Delaistre, after a design by Julien Leopold Boilly.

23

Modern Chemistry

- With the accomplishments of Lavoisier, the science of chemistry assumed a strict quantitative nature.
  - This allowed reliable predictions and reproducible experiments.

artist unknown

- Lavoisier died May 8, 1794
  - Because of his prominence in the pre-revolutionary government in France, he was beheaded at the height of the French Revolution

24

"Chemistry" – Links

- http://www.sciencetimeline.net
- http://www.chm.bris.ac.uk/webprojects2002/crabb/history.html
- http://www.crystalinks.com/alchemy.html
- http://www.alchemylab.com/history_of_alchemy.htm
- http://www.touregypt.net/metal1.jpg
- http://honolulu.hawaii.edu/distance/sci122/Programs/p23/p23.html#2.%20Ancient%20Chemical%20Skills
- http://www.levity.com/alchemy/
- http://www.3rd1000.com/history/alchemy.htm
- http://en.wikipedia.org/wiki/Alchemy_in_history
- http://www.taijichinesemedicine.com/gehong.htm

25

"Chemistry" – Links

- http://en.wikipedia.org/wiki/Chemistry_(etymology)
- http://www.sciencemuseum.org.uk/broughttolife/techniques/alchemy.aspx
- http://www.gettyimages.com/detail/51243861/Hulton-Archive
- http://www.columbia.edu/itc/chemistry/chem-c2507/navbar/chemhist.html
- http://en.wikipedia.org/wiki/History_of_science_and_technology_in_China
- http://www.historyforkids.org/learn/china/philosophy/confucius.htm
- http://www.monkeytree.org/silkroad/gunpowder/china1.html
- http://www.chm.bris.ac.uk/webprojects2002/crabb/history.html
- http://www.goldenelixir.com/
- http://www.historyworld.net/wrldhis/PlainTextHistories.asp?historyid=ac29

26

"Chemistry" – References

- http://www.taijichinesemedicine.com/gehong.htm
- http://commons.wikimedia.org/wiki/File:Roger-bacon-statue.jpg
- http://karenswhimsy.com/alchemy-symbols.shtm
- http://www.touregypt.net/science.htm
- http://commons.wikimedia.org/wiki/File:Paracelsus.jpg
- http://www.bbk.ac.uk/boyle/boyle_whatsnew/on_the_boyle_issue04.htm
- http://www.chemheritage.org/classroom/chemach/forerunners/lavoisier.html

27

Appendix G – Syllabus for HSTS 411

HISTORY OF SCIENCE
HSTS 411
Winter 2009
Instructor: Tim Reid, Ph.D.
Email: reidt@onid.orst.edu
Oregon State University
Milam 303B

Course Description and Rationale
This course will follow the history of science from its beginnings to the end of the Middle Ages. Students will identify and describe the main theories and discoveries that are the foundation of today's scientific establishment. This course will provide specific examples of how cultural influences have determined the direction of science as well as detailed illustrations of how scientific ideas and practices have helped determine the subsequent course of history.

The History of Science will be divided into several time-periods. Students will be able to recognize the distinctiveness of each period discussed. They will be able to identify the societal values and beliefs of each period and describe how these attitudes and values have influenced the way that science was practiced in each culture. Students will recognize that biases and other human influences can explain scientific practice, misconceptions, advances, and retreats. Students will be adept in making connections between culture and scientific practice. When appropriate, specific scientists will be used as examples of the different approaches that characterized specific time-periods.

Required Texts
All assigned readings will come from:
The Beginnings of Western Science by David C. Lindberg
and *The Closing of the Western Mind: The Rise of Faith and the Fall of Reason* by Charles Freeman

MODULES: Students will read all of the Blackboard modules. The Blackboard modules provide the most important course details. They are designed to give the student guidance and direction as well as provide an overall structure and focus to the course material. Modules are designed to prepare students for exams. The modules are online "lectures." These lectures will correct misplaced emphases and mistakes found in the text. The modules should be the main focus of this course. Blackboard modules can be found under the "Course Documents" tab.

SUMMARIES: A portion of the grade will come from summaries. A one-page summary of each module should be placed in the designated area when the student is finished with the module material. The summary should include the important concepts from the module. This encourages students to study with the intent of being able to summarize the module topics and to answer specific questions concerning class material. Summaries are designed to help the student assimilate the facts needed to support their answers to essay questions.

2. READING: Students will read *The Beginnings of Western Science* according to the "Course Outline." Readings have been chosen to facilitate learning. The student who reads as much as they can will do better in the course although the readings should not be the main focus. Each module summary should reflect a firm understanding of the module and may include specifics from the corresponding reading if appropriate.

Students should pace themselves while reading *The Closing of the Western Mind.* Reading a few chapters a week will help the students be prepared for the response paper that will be due near the end of the term.

4. MIDTERM: There will be an essay for the midterm. The essay will be based on the first five modules and first three chapters of Lindberg. Two questions can be found in the midterm folder; the student will answer one question. The questions have been worded in such a way as to generate thought. Appropriate answers will show that the student has adequately processed the material in question. Like all good essays, a position should be taken and facts from the course materials should be provided to support the thesis. Rote regurgitation of class material will not make a good essay.

5. RESPONSE PAPER: Students will be asked to read *The Closing of the Western Mind: The Rise of Faith and the Fall of Reason.* Students will submit a response paper in the designated area following the completion of Module Eight. The student will be required to submit an essay summarizing his or her views on Freeman's work. Remember to not got caught up in all the details. What is the big picture that each author is attempting to convey? What is the main lesson the author wants to teach? Explore these issues in a well-written essay and submit it to me.

6. **FINAL PAPER:** For the final paper, students will be asked to explain how the history described in this course has laid the foundations for the modern scientific enterprise. An appropriate paper will use suitable examples from each period to explain how ancient cultures, politics, religions, and philosophical ideas have shaped modern science.

REWRITES (not required): Appropriate comments that will help you improve your essays will be returned to you. Students are encouraged to revise their papers. Those who use constructive criticism accordingly will improve their grades. Rewrites are not required. However, if you wish to do a rewrite it will be due one week after the paper has been returned. (Please signify that your paper is a "rewrite" if you choose this option.)

ROUGH DRAFTS (not required): Rough drafts of the essays will be accepted before their due dates although they are not required. The same criterion for rewrites will be used for rough drafts.

REVISION POLICY: All work may be revised and turned in if you are not satisfied with the grade. You must show me that you have made real changes. To do this, submit the original graded assignment along with the revision and highlight the changes you made on your revision and write a summary of those changes. DO NOT just submit a revision where you have just added a few commas and corrected a few spellings. A revision must be improved in both ideas and conventions.

Grading

The midterm, the response paper, and final will each be worth 30% of your grade. The summaries will be worth 10% of your grade. Assignments will be given a point total and a letter grade. An assignment that receives a grade between 90 and 100 is an "A" paper; an assignment that receives a grade between 80-89 is a "B" paper, and so on. These point values are easily converted into a percentage grade in order for you to be able to keep track of your progress (i.e. an 98 is 98%). All grades will be added together accordingly in order to assess your final grade. Final grades will be as follows:

A grade of : 90-100% of all combined course material = A
80-89% of all combined course material = B
70-79% of all combined course material = C
60-69% of all combined course material = D
59% and below = F

Course Outline

Jan 5: Read Module 1 and Chapter 1 of Lindberg; Work on Freeman
Jan 12: Read Module 2; Work on Freeman
Jan 19: Read Module 3; Work on Freeman
Jan 26: Read Module 4 and Chapter 2 in Lindberg; Work on Freeman
Feb 2: Read Module 5 and Chapter 3 in Lindberg; Work on Freeman
MIDTERM
Feb 9: Read Module 6 and Chapters 4 & 5 in Lindberg; Work on Freeman
Feb 16: Read Module 7 and Chapter 6 in Lindberg; Work on Freeman
Feb 23: Read Module 8 and Chapter 7 in Lindberg; Finish Freeman
RESPONSE PAPER DUE
March 2: Read Module 9 and Chapters 8 in Lindberg
March 9: Read Module 10 and Chapters 10 & 11 in Lindberg
FINAL PAPER due March 18th by 5:00pm

SYLLABUS: Most questions are answered in the syllabus. Please learn the syllabus well. Knowing the syllabus will maximize your efficiency and effectiveness. If a question is answered in the syllabus, I will most likely refer you to it.

COMMUNICATION: You will need to communicate through your ONID webmail account. It is through ONID that I will send you announcements and other information regarding your work, the course, and your exams. Students sometimes miss important information when they neglect their OSU webmail. In order to do well, please communicate through the proper channels.

Plagiarism

You are expected to submit your own work in all your assignments, postings to the discussion board, and other communications, and to clearly give credit to the work of others when you use it. Academic dishonesty will result in a grade of "F." Link to Statement of Expectations for Student Conduct: http://oregonstate.edu/admin/stucon/achon.htm.

Students with Disabilities

Accommodations are collaborative efforts between students, faculty and Services for Students with Disabilities (SSD). Students with accommodations approved through SSD are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval through SSD should contact SSD immediately at 541-737-4098.

Course evaluation

We encourage you to engage in the course evaluation process each term – online, of course. The evaluation form will be available toward the end of each term, and you will be sent instructions by Ecampus. You will login to "Student Online Services" to respond to the online questionnaire. The results on the form are anonymous and are not tabulated until after grades are posted.

Appendix H – Syllabus for HSTS 412

Course Information

Description
THE SCIENTIFIC REVOLUTION
HSTS 412 (IDL): History of Science
Dr. John Zemel, Instructor

HSTS 412E is a four-credit course exploring the emergence of modern science in Europe between 1300 and 1800 A.D. Topics covered include changing ideas about nature and the cosmos; theoretical developments in astronomy, physics, and biology; the emergence of distinctive scientific methods; and the wider societal impacts of Newtonian science. At center stage is an account of the revolution in astronomy in the 200 years spanning the lives of Nicolas Copernicus, Johannes Kepler, Galileo Galilei, and Isaac Newton.

HSTS 412E is a part of the OSU Baccalaureate Core; successful completion of this course fulfills the requirement for study related to Science, Technology and Society. Students successfully completing the course will increase their knowledge of the nature of science as an enterprise; enlarge their understanding of the reciprocal impacts occurring among science, technology, religion, and other dimensions of society; and enhance their capacities for critical thinking.

PREREQUISITES AND ELIGIBILITY. Upper division standing is required, and completion of a lower division science sequence is recommended. HSTS 411 is not a prerequisite for this course. Full time on-campus Oregon State University students are not eligible for enrollment in this course.

TEXTBOOKS
The following texts are required as the basis of assigned readings for the course. The are available at the textbook counter of the Oregon State University bookstore, or from other book suppliers.

Butterfield, Herbert. The Origins of Modern Science: 1300-1800. Revised ed., 1957.

Dobbs, B. J. T. and M. C. Jacobs. Newton and the Culture of Newtonianism. 1994.

Koestler, Arthur. The Sleepwalkers; a History of Man's Changing Vision of the Universe. 1959.

Kuhn, Thomas The Copernican Revolution. 1985 (reissue).

Lindberg, David C. The Beginnings of Western Science. Second edition. 1992, 2008.

Format and Grading
The course is organized on a directed study format, requiring students to read in purchased texts and, at two- to three-week intervals, to prepare essays in response to specific assigned questions. Students also engage in discussion about events and issues covered in the course by responding in the Discussion Board to posted questions and to materials submitted by fellow students. Essays are the major determinant of grade; discussion activities represent 15 to 25 percent of course grade.

The learning objectives of this course are for students to become knowledgeable about 1) a range of ideas in astronomy, physics, and biology which had their origins in ancient Greece and which formed the foundation of ideas about nature in medieval Europe, and about 2) a range of individuals, social circumstances, and events ca. 1500-1800 A.D. which comprise a rejection of these ancient ideas and the beginning of modern scientific enterprise. Students are expected to be able to assimilate this information into a picture of how scientific ideas have arisen and evolved during this period in the history of western civilization known as the Scientific Revolution.

Grading will be based on an assessment of the learning in these areas which students are able to demonstrate, as measured in the composition of written essays and in contributions to discussion activities. In these assessments students will be expected to recognize and describe a range of figures, events, and ideas of interest, and to compare and evaluate the role they played in the growth of modern science.

WRITING SKILLS are not a formal consideration in determinations of grade. Nevertheless, to the extent that they foster or inhibit effective demonstration of student learning, writing skills can affect scores under any of the listed criteria. Be sure to view the course document "Preparation of Essays" (available in the Course Documents area).

LATE WORK is subject to reduction in grade.

INCOMPLETE grades are not available. Students are expected to plan their efforts wisely and to exercise withdrawal privileges when necessary.

Reading and Assignment Schedule
Readings and major assignments for the course are scheduled at intervals of two to three weeks. See the ASSIGNMENTS area for details.

Important Links
Important Links (6.192 Kb)

Appendix I – Grades for Course Work

Oregon State University

Corvallis, Oregon 97331-2130

SSN: *****7483 OSU ID: 931627354 Date of Birth: 03-FEB Date Issued: 17-JUN-2009

OFFC

Record of: Eileen Marie DiMauro Page: 1

Standard Mail

Issued To: Eileen M. DiMauro
44 Westbrook Ln
Pomona, CA 91766-4855

Course Level: Non-Degree / Credential

Current Program
College : Graduate School
Major : Non-Degree Graduate

SUBJ NO.	COURSE TITLE	CRED	GRD	PTS	R

INSTITUTION CREDIT:

Winter 2009

HSTS 411	*HISTORY OF SCIENCE	4.00	A	16.00

Ehrs: 4.00 GPA-Hrs: 4.00 QPts: 16.00 GPA: 4.00

Spring 2009

HSTS 412	*HISTORY OF SCIENCE	4.00	A	16.00

Ehrs: 4.00 GPA-Hrs: 4.00 QPts: 16.00 GPA: 4.00

********************** TRANSCRIPT TOTALS ***********************

	Earned Hrs	GPA Hrs	Points	GPA
TOTAL INSTITUTION	8.00	8.00	32.00	4.00
TOTAL TRANSFER	0.00	0.00	0.00	0.00
OVERALL	8.00			

********************** END OF TRANSCRIPT ***********************

Thomas Kent Kuo, Registrar